DOCUMENT RESUME

ED 344 105 CE 060 942

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TITLE Plant Science. Instructor Guide and Student Reference. Volume 24, Numbers 3 and 4.
INSTITUTION Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE Nov 91
NOTE 100p.
AVAILABLE FROM Instructional Materials Laboratory, University of Missouri, 2316 Industrial Drive, Columbia, MO 65202 (instructor guide, order no. 10-1005-I; student reference, order no. 10-1005-S).
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052) -- Guides - Classroom Use - Instructional Materials (For Learner) (051)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Agricultural Education; Competency Based Education; *Horticulture; Pests; Photosynthesis; *Plant Growth; Plant Identification; Plant Pathology; *Plants (Botany); Reproduction (Biology); Secondary Education; Teaching Guides; Weeds
IDENTIFIERS *Germination; Plant Physiology

ABSTRACT

This document consists of two separately published guides for a course on plant science: an instructor's guide and a student's reference manual. Each part consists of eight lessons and cover the following topics: (1) importance of plants; (2) classification of plants; (3) plant growth factors; (4) weeds, diseases, insects; (5) germination; (6) photosynthesis and respiration; (7) reproduction--sexual and asexual; and (8) plant genetics. Introductory matter in the instructor's guide includes the following: major competency profile; objectives; competencies; motivational technique or interest approach; evaluation; and references and materials. Each lesson in the instructor's guide contains some or all of the following: objective; study questions; references; teaching procedures--introduction, motivation, assignment, supervised study, discussion, other activities, conclusion, competency, answers to evaluation, and answers to work sheet; evaluation; and transparency masters. Each lesson in the student reference manual consists of lesson contents, summary, credits, tables, and figures. (NLA)

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MISSOURI AGRICULTURAL EDUCATION

10-1005-I

Instructor Guide

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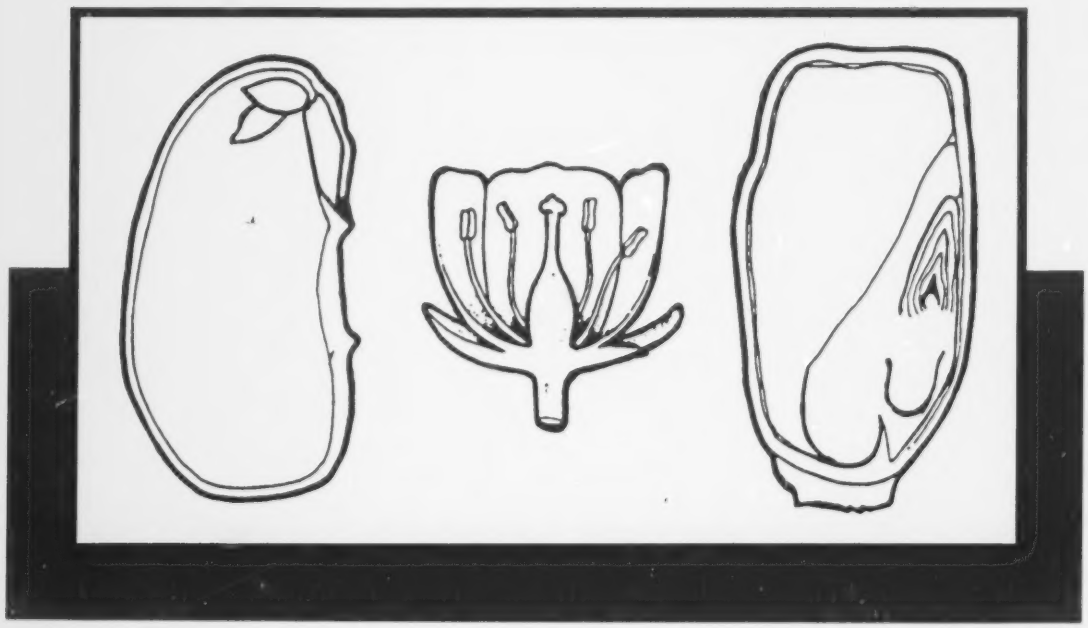

ED344105

CE060542

In cooperation with Agricultural Education
Department of Practical Arts and
Vocational-Technical Education
College of Education and
College of Agriculture, Food and Natural Resources
University of Missouri - Columbia

In cooperation with
Agricultural Education Section
Division of Vocational and Adult Education
Department of
Elementary and Secondary Education
Jefferson City, Missouri

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The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

Instructor Guide

PLANT SCIENCE

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Instructional Materials Laboratory
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Volume 24
Number 3

Catalog Number 10-1005-I
November 1991

ACKNOWLEDGMENTS

Recognition is given to advisory committee members for providing their valuable time and suggestions in developing this plant science unit. The committee consisted of Matt Biddle, Bob Buehler, Dan Forster, Steven King, Delbert Lund, Richard Mattas, Bob McGraw, Charles Parkes, Bill Roberts, Brenda Smith, and Jim Welker.

Appreciation is expressed to the following staff members of the Instructional Materials Laboratory for their efforts in producing this material: Harley Schlichting, Director; Amon Herd, Associate Director; Phyllis Miller, Assistant Director; Dan Stapleton, Assistant Director; Sharon Dyer, Graphic Designer; Lori Holliday and Tracy Stock, Word Processors; and Wei Li, Graduate Assistant.

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FOREWORD

The revision of the Plant Science unit is the result of suggestions by the MVATA Teaching Aids Committee. The Plant and Crop Science Advisory Committee suggested the topics to be included and reviewed the materials.

This instructor's guide and the corresponding student reference contain eight lessons: Importance of Plants; Classification of Plants; Plant Growth Factors; Weeds, Diseases, Insects; Germination; Photosynthesis and Respiration; Reproduction - Sexual and Asexual; and Plant Genetics. It is designed to be taught to ninth or tenth grade students. Transparency masters and work sheets have been included where appropriate. Additional student reference copies can be purchased separately.

During the summer of 1981, the Missouri State Board of Education formally adopted the concept of "Instructional Management Systems" (IMS) as a priority for the 1981-82 school year. The Missouri Commissioner of Education described the IMS concept as a practical way of "organizing for excellence" in education. To meet the demand for greater productivity and accountability, the director of Vocational Education applied the elements of IMS to form the Vocational Instructional Management System (VIMS). The VIMS process provides a framework to use in planning and organizing to assure excellence in Missouri's vocational education system by focusing greater attention on the management of teaching and learning.

This guide incorporates the needed component parts to aid agriculture teachers in the implementation of VIMS. For ease of use, performance objectives and competencies have been included at the beginning of the unit as well as incorporated within each lesson. A competency profile has been provided in the front of the guide for convenient record keeping.

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UNIT - PLANT SCIENCE

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OBJECTIVES

1. The student will be able to identify the importance of plants.
2. The student will be able to list and describe methods to classify plants.
3. The student will be able to describe factors that affect plant growth and development.
4. The student will be able to describe how pests affect plant growth.
5. The student will be able to identify the steps in germination of monocot and dicot seeds.
6. The student will be able to describe basic plant processes.
7. The student will be able to describe how plants reproduce sexually and asexually.
8. The student will be able to describe how genetics influences plant growth.

NOTE: Percent of accuracy should be set by instructors to reflect passing grades within their school systems.

COMPETENCIES

1. Identify the importance of plants.
2. List and describe methods to classify plants.
3. Describe factors that affect plant growth and development.
4. Describe how pests affect plant growth.
5. Identify the steps in germination of monocot and dicot seeds.
6. Describe basic plant processes.
7. Describe how plants reproduce sexually and asexually.
8. Describe how genetics influences plant growth.

MOTIVATIONAL TECHNIQUE OR INTEREST APPROACH

1. Ask students what products are made directly or indirectly from plants. List their responses on the chalkboard.
2. Obtain some fast or quick start seeds from a seed store. Assist the students in germinating the seeds. Once the seeds have germinated, have students identify the different parts of the seedling.
3. Obtain a plant that is fairly salt tolerant (e.g., Easter lilies) and a plant that is not salt tolerant. Using a mild salt-water solution, water both plants. Keep track of the number of days it takes for any adverse effects to show up on the plants. Did it affect the plants differently?

EVALUATION

1. Give short, objective tests following each lesson and a more in-depth objective test at the conclusion of the unit.
2. Observe the changes in behavior as evidence of an improved ability of students to deal with problems in this unit using background information acquired from earlier units.
3. Observe students' attempts to solve similar problems in their supervised agricultural experience programs.

REFERENCES AND MATERIALS

1. Student Reference

Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.

2. Teacher References

a) Agrios, G.N. Plant Pathology. 3rd ed. New York, NY: Academic Press, 1988.

b) Bishop, D.D.; S.R, Chapman; L.P. Carter. Working in Plant Science. NY: McGraw-Hill, 1978.

c) Cooper, E.L. Agriscience: Fundamentals and Applications. Albany, NY: Delmar Publishers Inc., 1990.

d) Fridline, C.R.; C. Miller. Plant Growth and Development. Columbus, OH: Ohio Agricultural Education Curriculum Materials Service, 1989. (available from the Instructional Materials Laboratory, University of Missouri-Columbia)

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h) Rothenberger, R.R. Starting Plants from Seeds. Guide #6570. Columbia, MO: University Extension.

i) Sattelle, D.B. Biotechnology in Perspective. New York, NY: VanNostrand Reinhold Co., 1988. (available from the Missouri Vocational Resource Center)

j) Walton, P.D. Principles and Practices of Plant Science. NJ: Prentice-Hall, 1988.

k) Wells, J.A.; J. Anderson. Greenhouse Operation and Management. University of Missouri-Columbia: Instructional Materials Laboratory, 1990.

3. Audiovisuals (available from the Missouri Vocational Resource Center, University of Missouri-Columbia, 10 London Hall, Columbia, MO 65211)

a) Photosynthesis and Respiration. video. Vocational Education Productions, 1987.

b) Plant Propagation Vol. I. video. Vocational Education Productions, 1987

c) Plant Propagation Vol. II. video. Vocational Education Productions, 1987.

4. Movies (available from the Audiovisual Library, Academic Support Center, University of Missouri-Columbia, 505 E Stewart Rd., Columbia, MO 65211)

a) Growth of Seeds

b) Photosynthesis

c) Photosynthesis and the Respiration Cycle

d) Plants Make Food

e) Role of the Green Plants

f) Seed Germination

5. Computer Software

a) Agriculture Math Tutor/Crop. ACS Software Publishing, 256 Warner Milne Rd. #4, P.O. Box 5934, Oregon City, OR 97045.

b) Agri ID (leaf and plant). Midwest Agribusiness Services, Incl, 6739 Glacier Drive, West Bend, WI 53095.

c) Calculating Soil Loss. Agri-Education, Inc., Box 456, Stratford, IA 50249.

d) Common Cents Conservation. Agri-Education, Inc., Box 456, Stratford, IA 50249.

e) Conservation Tillage. Agri-Education, Inc., Box 456, Stratford, IA 50249.

f) Hobar Forestry/Related Review. Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112.

g) Soil Evaluation/Fertility/Related Review. Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112.

PLANT SCIENCE
Major Competency Profile

Directions: Evaluate the student by checking the appropriate number or letter to indicate the degree of competency. The rating for each task should reflect **employability readiness** rather than the grades given in class.

Rating Scale:
3 Mastered - can work independently with no supervision
2 Requires Supervision - can perform job completely with limited supervision
1 Not Mastered - requires instruction and close supervision
N No Exposure - no experience or knowledge in this area

3	2	1	N	Competencies
				1. Identify the importance of plants.
				2. List and describe methods to classify plants.
				3. Describe the factors that affect plant growth and development.
				4. Describe how pests affect growth.
				5. Identify the steps in germination of monocot and dicot seeds.
				6. Describe basic plant processes.
				7. Describe how plants reproduce sexually and asexually.
				8. Describe how genetics influences plant growth.

UNIT - PLANT SCIENCE

Lesson 1: Importance of Plants

Objective: The student will be able to identify the importance of plants.

Study Questions

1. **Why are plants important?**
2. **What role do plants play in the environment?**
3. **Where did common crop plant species originate?**
4. **How are plants used?**

Reference

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.

UNIT - PLANT SCIENCE

Lesson 1: Importance of Plants

TEACHING PROCEDURES

A. Introduction

Plants are vital for the survival of humans. The role of plants, their parts and functions, and the benefits they provide in relation to people will be discussed. This unit will introduce students to the plant world and how it continues to meet the world's needs.

B. Motivation

Bring into the classroom a dried ear of corn that is used for either feed or food crop seed. Remove the grain from the ear and ask the class how people benefit from the grain. Explore every benefit that grain provides. Examples include food for livestock that in turn provides people more food, food for humans in many forms (canned, raw, ground, popped, etc.), stalks left in the field to protect against soil erosion, starch from the corn to be used in biodegradable plastic products, and ethanol for alternative fuels.

C. Assignment

D. Supervised study

E. Discussion

1. Most plants can survive on their own without any assistance from humans. However, people depend on plants every day. List examples of each type of plant.

Why are plants important?

a) Production of food crops (human and livestock)
b) Production of fiber crops
c) Beneficial to the environment

2. A common misconception about plants and their benefits is that they only provide food. Fortunately, plants do much more.

What role do plants play in the environment?

a) Production of oxygen
b) Reservoir for carbon compounds (carbon sinks)
c) Prevention of soil erosion (windbreak)
d) Increase soil organic matter and soil quality
e) Beautification (trees and flowers)
f) Sound barriers
g) Recreational surfaces (turf)
h) Visual barriers

3. A variety of crops are produced in the U.S. and exported to many parts of the world. However, many plants originated from other countries.

Where did common crop plant species originate?

a) Corn - Mexico
b) Soybeans - China
c) Wheat - Southwestern Asia (Euphrates and Tigris Valleys)
d) Oats - Eastern Europe or Western Asia
e) Barley - Abyssinia and Southeastern Asia
f) Potatoes - South America
g) Rice - Southeast Asia
h) Peanuts - Brazil
i) Cotton - India, Mexico
j) Sorghums - Africa and India
k) Flax - Mesopotamia, Assyria, Egypt

4. Researchers in plant science continue to work to discover new information about plants and how they grow and reproduce. New methods, processes and products have been the result of the work of plant scientists.

How are plants used?

a) Production of food, feed, and fiber crops (including lumber and pulp)
b) Research (biotechnology and crossbreeding)
c) Nonfood products (medicines, clothing, rubber, perfumes, and spices)
d) Beautification

F. Other activities

1. Have students choose one crop plant species from an instructor-generated list and prepare a written and/or oral report. Include the following information in the report.

a) History
b) Origin
c) Production areas in the world
d) Botanical characteristics
e) Varieties
f) Products from species
g) Economical importance

2. Bring in an assortment of common crop plant species from the local area to discuss in class. Possibly demonstrate grinding corn or wheat.

NOTE: It may be necessary to begin an early collection of these plants during specific harvest times in order to have them available for class.

G. Conclusion

For as long as people have been aware of their existence, plants have provided a source of food for human survival. From feeding multitudes to protecting the environment, plant research continues to play a vital role in the world.

H. Competency

Identify the importance of plants.

I. Answers to Evaluation

1. True
2. False
3. True
4. False
5. a
6. a
7. b
8. a
9. a
10. a
11. a
12. b
13. a
14. c

UNIT - PLANT SCIENCE

Name _____

Lesson 1: Importance of Plants

Date _____

EVALUATION

True/False (Place the correct response in the blank provided.)

____ 1. Plants are a vital part in the agricultural food chain.

____ 2. Nylon is a plant fiber product.

____ 3. Plants produce oxygen.

____ 4. Animals can produce their own energy.

Matching (Write the letter indicating the type of crop in the blank before each crop listed.)

Food Crop = A
Fiber Crop = B
Forage Crop = C

5. ____ Corn

6. ____ Wheat

7. ____ Flax

8. ____ Sorghum

9. ____ Peanuts

10. ____ Rice

11. ____ Soybeans

12. ____ Cotton

13. ____ Barley

14. ____ Alfalfa

UNIT - PLANT SCIENCE

Lesson 2: Classification of Plants

Objective: The student will be able to list and describe methods to classify plants.

Study Questions

1. **How can plants be classified?**
2. **What is the botanical system of classification?**
3. **Why is the botanical classification system important?**
4. **How do monocots and dicots differ?**
5. **What is a legume?**
6. **How do the life cycles of plants differ?**

References

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.
2. Transparency Masters
   a) TM 2.1: Botanical Classification (Wheat and Barley Example)
   b) TM 2.2: Comparison of Dicots and Monocots

UNIT - PLANT SCIENCE

Lesson 2: Classification of Plants

TEACHING PROCEDURES

A. Review

In Lesson 1, the importance of plants was discussed. In this lesson, plant classification will be discussed. Humans have a tendency to organize information and categorize items into groups. This process helps to simplify what could be a confusing situation. Plant classification is a means by which plants are organized and categorized. Plant classification helps people understand the plant world and how plants are related to each other.

B. Motivation

1. Bring into the classroom several different types of plants (e.g., vines, grasses, woody, herbaceous, and flowering plants). Have students identify the characteristics of each sample. Organize and list on the board the characteristics and uses that students identify. When completed, ask students whether their notes would be understood if copied and sent to another country. If not, why? Relate this entire exercise to the topic of early methods of classification.

2. Bring in examples of plants with different common names. Examples include butterprint (velvetleaf, buttonweed), alfalfa (lucerne), and redroot (pigweed). Point out how using the botanical name can avoid confusion when identifying plants.

C. Assignment

D. Supervised study

E. Discussion

1. Plants have many forms and functions. Classification is a means of grouping plants according to their similarities.

How can plants be classified?

a) Botanical - a classification system that identifies plant species and groups them according to their physical characteristics.
b) Descriptive - a classification system that identifies plants by such things as their use (e.g., food crops, feed crops, ornamental crops) and their life cycle (e.g., annual, perennial).

2. Continued research with plants is vital. There are approximately 500,000 different species in the plant kingdom. Classification systems help eliminate confusion among researchers. Botanical classification plays a beneficial role in international research. (Use TM 2.1.)

What is the botanical system of classification?

a) An internationally accepted system that places plants into discrete categories.
b) It uses a system of eight categories.
   1) Kingdom

2) Division
3) Class
4) Subclass
5) Order
6) Family
7) Genus
8) Species

3. There are hundreds of thousands of plants on this planet. Humans depend on many of these plants for survival.

Why is the botanical classification system important?

a) It clearly identifies plant species.
b) It identifies how plant species differ from other members of the plant kingdom.
c) It is a universal language.

4. Plants that are produced as food for humans or feed for livestock are called crop plants. To better understand crop plants, their parts, and their functions, they have been divided into two groups: monocotyledons and dicotyledons. (Use TM 2.2.)

How do monocots and dicots differ?

a) Monocots (corn, wheat)
   1) One cotyledon in a seed
   2) Leaves with parallel veins
   3) Vascular bundles scattered throughout stems; no vascular cambium
   4) Root system composed of many fibrous roots with many root hairs
   5) Flower parts in 3s or multiples of 3
b) Dicots (soybeans, alfalfa)
   1) Two cotyledons in each seed
   2) Leaves with network of veins
   3) Vascular bundles forming a ring around outside of stem
   4) Root system composed of primary tap root and many root hairs
   5) Flower parts in 4s or 5s or multiples of 4 or 5

5. All crop plants need nutrients for proper growth and development. Nitrogen (N), phosphorous (P), and potassium (K) are the three primary nutrients that are needed. As a rule, primary nutrients are supplied to plants through the application of commercial fertilizers. However, legumes are quite different.

What is a legume?

a) A family of plants whose seeds are formed in fruit and the fruits are formed in pods.
b) Some have the ability to obtain nitrogen from the soil air.

6. Throughout the life of a plant there are several stages of plant growth. The first stage begins when the seed is planted and the last stage involves the production of more seed. This process is called a life cycle. Life cycles differ depending on the plant.

How do the life cycles of plants differ?

a) Annuals - complete life cycle occurs in one growing season
   1) Summer - seeded in spring, harvest in fall (corn, etc.)

2) Winter - seeded in late summer, harvest the following summer (winter wheat, etc.)

b) Biennials - complete life cycle occurs over two growing seasons (sugar beets, carrots)

c) Perennials - live year after year (many forage and pasture crops, shrubs, and some flowers)

F. Other activities

1. Have the class start a collection of dried beans that can be classified by genus and species. (This can be done in small, clear baby food jars.)

2. Have students select, from a teacher-generated list, one plant and do a report on its origin and botanical classification.

G. Conclusion

Botanical and descriptive classification systems can be used to classify plants. Both methods help us understand more about the plant world. With continued research, a better understanding of plants will continue to enable farmers to provide food that humans need for survival.

H. Competency

List and describe methods to classify plants.

I. Answers to Evaluation

1. False
2. False
3. True
4. 2 Division
5. 1 Kingdom
6. 3 Class
7. 4 Subclass
8. 6 Family
9. 5 Order
10. 8 Species
11. 7 Genus
12. D
13. M
14. M
15. D
16. B
17. WA
18. B
19. P
20. SA

UNIT - PLANT SCIENCE Name _____

Lesson 2: Classification of Plants Date _____

EVALUATION

True/False (Place the correct response in the blank provided.)

____ 1. Botanists use the descriptive system of classification.

____ 2. Descriptive classification involves genus and species levels of identification.

____ 3. Descriptive classification deals mainly with crop plants.

Number the classification levels in correct order. (1 being the broadest level and 8 being the most specific level.)

____ 4. Division

____ 5. Kingdom

____ 6. Class

____ 7. Subclass

____ 8. Family

____ 9. Order

____ 10. Species

____ 11. Genus

Identify the following plant characteristics as either monocot (M) or dicot (D).

____ 12. Two cotyledons

____ 13. Leaves with parallel veins

____ 14. Stems without vascular cambium and with scattered vascular bundles

____ 15. Flower parts in 4s or 5s or multiples of 4 or 5

Identify the following statements with the correct plant life cycle: Summer Annuals = SA; Winter Annuals = WA; Biennial = B; Perennial = P.

____ 16. Require two years to complete their life cycles

____ 17. Seeded in the late summer or early fall, harvested the following summer

____ 18. Develops flowers the second year only

____ 19. Returns each year without replanting

____ 20. Seeded in the spring, harvested in the fall

TM 2.1

Botanical Classification
(Wheat and Barley Example)

	WHEAT	BARLEY
1. KINGDOM	Plantae (plant, distinct from animal)	Plantae (plant, distinct from animal)
2. DIVISION	Spermatophyta (or seed plants)	Spermatophyta (or seed plants)
3. CLASS	Angiosperma (or plants with their seeds in a fruit)	Angiosperma (or plants with their seeds in a fruit)
4. SUBCLASS	Monocotyledonae (seed with single seed leaf)	Monocotyledonae (seed with single seed leaf)
5. ORDER	Graminales (grass-like families)	Graminales (grass-like families)
6. FAMILY	Graminae or Graminaceae (the grasses)	Graminae or Graminaceae (the grasses)
7. GENUS	Triticum (the wheats)	Hordeum (the barleys)
8. SPECIES	aestinum (bread wheat)	vulgare (barley)

Dicots vs. Monocots

DICOT (e.g., Bean)

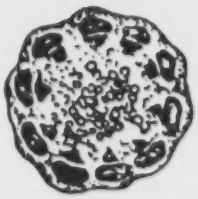
Two cotyledons

MONOCOT (e.g., Corn)

One cotyledon

Leaves with network of veins

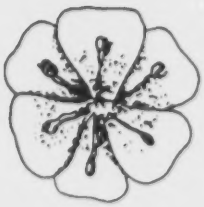
Leaves with parallel veins



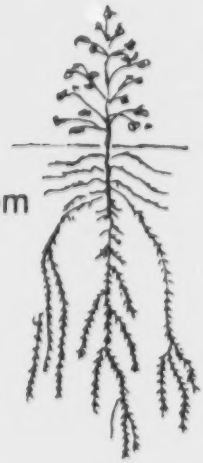
Stems with vascular bundles in a ring

Stems with randomly scattered vascular bundles

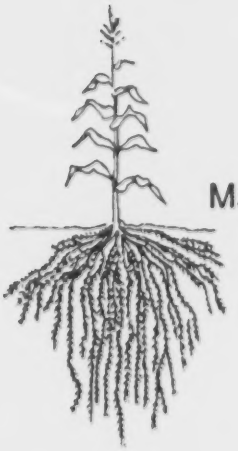
Flower parts in 4s or 5s or multiples of 4 or 5



Flower parts in 3s or multiples of 3



Mature root system



Mature root system

UNIT - PLANT SCIENCE

Lesson 3: Plant Growth Factors

Objective: The student will be able to describe factors that affect plant growth and development.

Study Questions

1. **What factors affect plant growth?**
2. **How does light affect the processes of plant growth?**
3. **What role does water play in plant growth?**
4. **What elements are necessary for plant growth?**
5. **What methods are used by plants to obtain nutrients?**
6. **How is plant growth affected by temperature?**

Reference

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.

UNIT - PLANT SCIENCE

Lesson 3: Plant Growth Factors

TEACHING PROCEDURES

A. Review

Review Lesson 2. In order to discuss plant growth, it first must be defined. Secondly, from an agricultural perspective, measuring that growth becomes very important. Finally, understanding factors that contribute to plant growth process enables humans to better control plants in the production of food and fiber products.

B. Motivation

Using two small flats (horticultural container for planting seed), plant bean seeds to germinate. Water one flat, and place it in a sunny spot for warmth. The other flat should not be watered and should be placed away from the sun in a cooler spot. Have students keep a record of the time it takes the seeds in each flat to germinate. Discuss possible problems and solutions to this demonstration, and relate the demonstration to the topic.

C. Assignment

D. Supervised study

E. Discussion

1. Plant growth is an irreversible process during a plant's life that increases plant volume or dry weight or both. The growth process of a plant is dependent on several factors.

   What factors affect plant growth?

   a) Light
   b) Water
   c) Nutrients
   d) Temperature

2. Of the factors that affect plant growth, light is one that controls other processes within the plant.

   How does light affect the processes of plant growth?

   a) Photosynthesis - In the presence of light, plants manufacture food using water and carbon dioxide.
   b) Phototropism - Light stimulates the longitudinal growth in plant stems through this process.
   c) Photoperiodism - In some plants, light triggers the development of flowers.

3. Plants require water. Some plants, namely desert-type plants, can survive with very little water.

   What role does water play in plant growth?

   a) Makes up a large percentage of the plant's fresh weight

b) Transports nutrients throughout the plant
c) Involved in many chemical reactions

4. Humans need certain vitamins and minerals in their diets for proper growth and development of bones, muscles, and skin and also to heal the body after an injury. Plants also need nutrients for growth and development.

What elements are necessary for plant growth?

a) Elements from air
   1) carbon
   2) hydrogen
   3) oxygen
b) Primary macronutrients
   1) Nitrogen
   2) Phosphorus
   3) Potassium
c) Secondary macronutrients
   1) Calcium
   2) Magnesium
   3) Sulfur
d) Micronutrients
   1) Iron
   2) Manganese
   3) Boron
   4) Copper
   5) Zinc
   6) Molybdenum
   7) Chlorine

5. Nutrients that aid in the proper growth and development of plants must be available to the plant.

What methods are used by plants to obtain nutrients?

a) Absorption is the process through which plant roots absorb nutrients and water from the soil.
b) Translocation is the movement of nutrients and water throughout the plant.

6. Heat can influence plant growth both positively and negatively.

How is plant growth affected by temperature?

Temperatures above or below the optimum will reduce plant growth.
a) Temperatures below optimum cause a decrease in gaseous exchanges; diffusion and osmosis slow down because the permeability of membranes is more difficult.
b) As the temperature rises above optimum, enzymes become less stable and break down causing plant inactivity.

F. Other activities

1. Have students place a plant in the window and observe how the plant moves towards the light over the period of a few days. Discuss with students phototropism and its causes.

2. Obtain white carnations. Allow the carnations to sit without water for a few hours. Then, place them in water dyed with food coloring (red, blue). Discuss with students phloem and xylem tissues. Explain how water helps transport needed nutrients throughout the plant.

G. Conclusion

Understanding the factors involved in plant growth enables scientists, agronomists, and farmers to produce crops. Factors such as light, water, nutrients, and temperature all play a vital role in plant growth and development.

H. Competency

Describe factors that affect plant growth and development.

I. Answers to Evaluation

1. False
2. True
3. False
4. True
5. d
6. b
7. b
8. Primary macronutrients: (can be in any order)
   a. Nitrogen
   b. Phosphorus
   c. Potassium
9. Secondary macronutrients: (can be in any order)
   a. Calcium
   b. Magnesium
   c. Sulfur
10. Micronutrients (can be in any order)
   a. Boron
   b. Manganese
   c. Copper
   d. Zinc
   e. Iron
   f. Chlorine
   g. Molybdenum

UNIT - PLANT SCIENCE Name _____

Lesson 3: Plant Growth Factors Date _____

EVALUATION

True/False (Place the correct response in the blank provided.)

____ 1. Environment has very little effect on plant growth.

____ 2. Photosynthesis requires sunlight, water, and carbon dioxide.

____ 3. Colder temperatures increase plant growth.

____ 4. Plant growth is related to temperature.

Circle the letter that corresponds to the best answer.

5. Which process changes carbon dioxide and water into sugar?

a. Osmosis
b. Phototropism
c. Diffusion
d. Photosynthesis

6. In which process does the growing part of the plant move toward the sunlight?

a. Absorption
b. Phototropism
c. Photosynthesis
d. Photoperiodism

7. The plant's reaction to light in stimulating flower development is related to _____.

a. Photosynthesis
b. Photoperiodism
c. Phototropism
d. Osmosis

Essential elements can be categorized depending upon the amount needed by the plant. Place the correct element in the blanks beneath each category.

8. Primary macronutrients

a. _____

b. _____

c. _____

9. Secondary macronutrients

a. _____

b. _____

c. _____

10. Micronutrients

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

UNIT - PLANT SCIENCE

Lesson 4: Weeds, Diseases, Insects

Objective: The student will be able to describe how pests affect plant growth.

Study Questions:

1. **What pests cause problems with plants?**
2. **How do weeds affect plant growth?**
3. **How do diseases affect plant growth?**
4. **What three conditions must be present for a disease to develop?**
5. **How do insects inhibit plant growth?**

Reference

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.

UNIT - PLANT SCIENCE

Lesson 4: Weeds, Diseases, Insects

TEACHING PROCEDURES

A. Review

Review Lesson 3. Describe how light, water, nutrients, and temperature affect plant growth. Discuss the importance of the plant's leaves, stems, and roots to its survival.

B. Motivation

Bring into class several examples of plants injured by insects. Find some leaves or a branch that is infested with aphids, and discuss why the insects are on the plant. Relate this to the millions of dollars spent every year to control pests in food and fiber crops.

C. Assignment

D. Supervised study

E. Discussion

1. For as long as humans have been growing plants for food, pests have caused problems with plant growth.

   What pests cause problems with plants?

   a) Weeds
   b) Diseases (pathogens)
   c) Insects (predators - insects and larger animals)

2. A weed can be defined as any unwanted plant. Weeds may be unsightly in a lawn or field; however, they also compete with desirable plants in many ways.

   How do weeds affect plant growth?

   a) Compete for light
   b) Compete for water
   c) Compete for nutrients

3. Plant growth depends on many external factors and processes inside the plant. Diseases that infect plants can inhibit plant growth in many ways.

   How do diseases affect plant growth?

   a) Interfere or inhibit photosynthesis
   b) Stunt plant growth
   c) Cause structural damage
   d) Reduce crop yields
   e) Reduce crop quality

4. Much research has been conducted to reduce disease problems in plants. Many plant diseases can be prevented by using good management practices. Disease prevention or control measures should focus on eliminating one or more of the three conditions necessary for a disease to develop.

What three conditions must be present for a disease to develop?

a) Susceptible host - a weakened plant
b) Virulent pathogen - a disease carrying organism capable of attacking a susceptible host
c) Favorable environment - an environment that enhances contact between the susceptible host and virulent pathogen

5. Insects damage plants and disrupt the plant's growth and development. Through a better understanding of how insects damage plants, more efficient techniques of control can be used.

How do insects inhibit plant growth?

a) Physical damage
    1) Eating plant tissue
    2) Sucking plant juices
b) Physiological damage
    1) Transmitting viruses to plant
    2) Depositing eggs into plant and disrupting natural processes

F. Other activities

1. Have each student select an insect from an instructor-generated list and prepare a written report on its life cycle and its effect on plants.

2. Have each student select one plant disease from an instructor-generated list and prepare a written report on its effect on plant growth.

3. Depending on the time of year (warm weather), take a field trip around the school campus and locate insects that are on plants. Observe the eating habits of these insects.

G. Conclusion

Food is a vital commodity that all humans need. Plants and their ability to grow are greatly affected by pests. Weeds, diseases, and insects continue to damage food and fiber crops each year. By understanding how pests can damage plants, more efficient and successful techniques to control and prevent damage can be used.

H. Competency

Describe how pests affect plant growth.

I. Answers to Evaluation

1.	False	5.	True
2.	True	6.	d
3.	True	7.	b
4.	True	8.	a

UNIT - PLANT SCIENCE Name _____

Lesson 4: Weeds, Diseases, Insects Date _____

EVALUATION

True/False (Place the correct response in the blank provided.)

____ 1. Plant pests are limited to only insects that damage crops.

____ 2. Grass in a corn field is considered a pest.

____ 3. Insects can transmit diseases to plants.

____ 4. Diseases may disrupt healthy plant growth.

____ 5. Damaged or weakened plants are more susceptible to disease.

Circle the letter that corresponds to the best answer.

6. Why are weeds considered pests?

   a. They are plants also.
   b. They can produce their own food through photosynthesis.
   c. They are immune to many crop diseases.
   d. They steal needed nutrients from crops.

7. What three conditions must be present for a disease to develop?

   a. Soil nutrient deficiency, environmental condition, susceptible host
   b. Susceptible host, favorable environmental conditions, virulent pathogen
   c. Virulent pathogen, cold climate, soil nutrient deficiency
   d. Hot, dry conditions, virulent pathogen, soil nutrient deficiency

8. What does physiological damage to plants by insects refer to?

   a. Disrupting the internal natural processes of the plant
   b. Damaging the root structure of the plant
   c. Damaging the plant's leaves
   d. Entering into the inside of the stem and eating the tissue

UNIT - PLANT SCIENCE

Lesson 5: Germination

Objective: The student will be able to identify the steps in germination of monocot and dicot seeds.

Study Questions

1. **What is a seed?**
2. **What are the requirements for germination?**
3. **How does a seed germinate?**
4. **What are the parts and functions of a monocot seed?**
5. **What are the parts and functions of a dicot seed?**
6. **What are the processes of germination and emergence in monocot and dicot seeds?**

References

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.
2. Transparency Masters
   a) TM 5.1: Monocot Seed (Corn) and Its Parts
   b) TM 5.2: Dicot Seed (Bean) and Its Parts
   c) TM 5.3: Stages in Germination and Emergence of a Monocot Seed (Corn)
   d) TM 5.4: Stages in Germination and Emergence of a Dicot Seed (Bean)
3. Movies (From the Academic Support Center, University of Missouri-Columbia)
   a) Seed Germination
   b) Growth of Seeds

UNIT - PLANT SCIENCE

Lesson 5: Germination

TEACHING PROCEDURES

A. Review

Review Lesson 4. Describe how weeds, insects, and diseases may be harmful to plant growth.

B. Motivation

1. Bring into class examples of seeds: popcorn in a jar or bag, salted pumpkin seeds, salted sunflower seed, roasted peanuts, a can of pinto beans, and a bag of dried beans. Discuss with students the importance of seeds as a food source. Also, discuss the role of seeds in food production.

2. A few days before this lesson begins, place several seeds on wet paper towels. The number of days will depend on the kind of seeds. As seeds begin to germinate, dissect them and identify their parts.

C. Assignment

D. Supervised study

E. Discussion

1. Seeds are very important in providing food for the world. Seeds are the beginning of the food production process. Discuss with the class what they think a seed is and record their responses on the chalkboard.

What is a seed?

A seed is a young embryonic plant in a dormant or resting stage with a supply of food and one or more seed coats. Basic parts include:

a) Embryo
b) Food supply
c) Ovary wall or seed coat (protection)

2. Germination does not just happen without cause. A viable seed in the dormant or resting stage is able to begin growth only when certain environmental conditions are present.

What are the requirements for germination?

a) Favorable temperature - varies depending on crop species
b) Sufficient moisture
c) Air (or oxygen)
d) Presence or absence of light (depending on the plant species)

3. The process of germination involves several steps. View film on "Germination."

How does a seed germinate?

a) The seed absorbs water.
b) The seed's proteins are activated, which activates the enzyme system.
c) The seed's root (radicle) emerges.
d) The seed's plumule or embryonic shoot begins to emerge.
e) Leaves form and food production via photosynthesis starts.

4. Monocotyledonous and dicotyledonous seeds are different in their parts and functions. Use TM 5.1 to describe the differences.

What are the parts and functions of a monocot seed?

a) Seed coat - protection
b) Endosperm - a source of starch or energy (food) for the young plant during germination
c) Embryo - miniature plant containing:
    1) Cotyledon or scutelum - helps break down the starch in the endosperm for feeding the embryo
    2) Epicotyl - shoot above cotyledon - above ground
    3) Hypocotyl - part of stem below the cotyledon
    4) Radicle - the primary root, which dies soon after permanent roots grow; absorbs water; supports the seedling

5. Monocotyledonous and dicotyledonous seeds are different in their parts and functions. Use TM 5.2.

What are the parts and functions of a dicot seed?

a) Seed coat - protection
b) Embryo - miniature plant containing:
    1) Two cotyledons - seed leaves; food storage
    2) Epicotyl - first true leaves, shoot, and everything above the cotyledon
    3) Hypocotyl - first true stem between root and first node of the stem; pulls the seed upward
    4) Radicle - forms the root system; absorbs water

6. When planning what seeds to plant, germination requirements and seed emergence need to be considered. Some dicot seeds like peanuts and peas have hypogeal emergence, but most dicot seeds have epigeal emergence. The steps for epigeal emergence are given below. View film on "Growth of Seeds." Use TMs 5.3 and 5.4.

What are the processes of germination and emergence in monocot and dicot seeds?

a) Monocot - corn
    1) Seed swells as moisture is absorbed, and seed coat ruptures.
    2) Radicle (temporary root) grows down.
    3) First internode and epicotyl grows upward.
    4) After epicotyl emerges, new leaves form and food production starts.
    5) New root system develops above the first internode just beneath soil.
    6) Temporary root system ceases to function and dies.
b) Dicot - bean
    1) Seed swells as moisture is absorbed; seed coat ruptures.

2) Radicle grows down.
3) Hypocotyl elongates, forms an arch that breaks soil surface.
4) When hypocotyl reaches light, elongation ceases and hypocotyl straightens up, pulling cotyledons out of soil.
5) Cotyledons turn green and manufacture food until new leaves develop.
6) As new leaves develop, the cotyledons die, dry up, and fall off.

F. Other activities

1. Split open several different types of monocot and dicot seeds and identify the parts.

2. Germinate corn and bean seeds to observe differences in their emergence. (Use a view box for this if possible.)

G. Conclusion

Seeds are vital for food production. Germination will occur when a viable seed is exposed to favorable temperature, sufficient moisture, and oxygen. Monocot and dicot seed requirements for germination are the same; however, the type of emergence for each is quite different. The differences in emergence will dictate the optimum time for planting.

H. Competency

Identify the steps in germination of monocot and dicot seeds.

I. Answers to Evaluation

1. False
2. True
3. False

Monocot Identification

4. endosperm
5. cotyledon
6. epicotyl
7. hypocotyl
8. radicle
9. seed coat
10. embryo

Dicot Identification

11. seed coat
12. epicotyl
13. hypocotyl
14. radicle
15. cotyledon
16. embryo

UNIT - PLANT SCIENCE

Name _____

Lesson 5: Germination

Date _____

EVALUATION

True/False (Place the correct response in the blank provided.)

____ 1. All seeds will germinate if sufficient moisture is present.

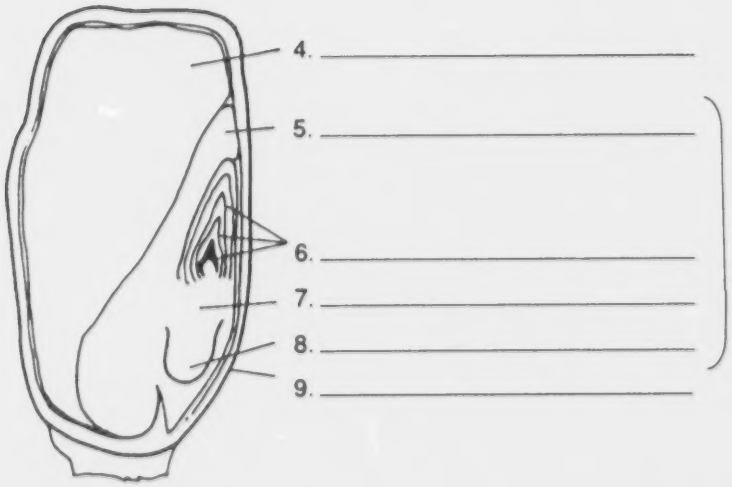
____ 2. Many kinds of seeds are eaten as food throughout the world.

____ 3. The monocot seed contains two cotyledons that store food for the young plant.

Identify the following parts.

Monocot Seed (Corn)

Parts
Seed coat
Endosperm
Embryo
Radicle
Cotyledon
Epicotyl
Hypocotyl

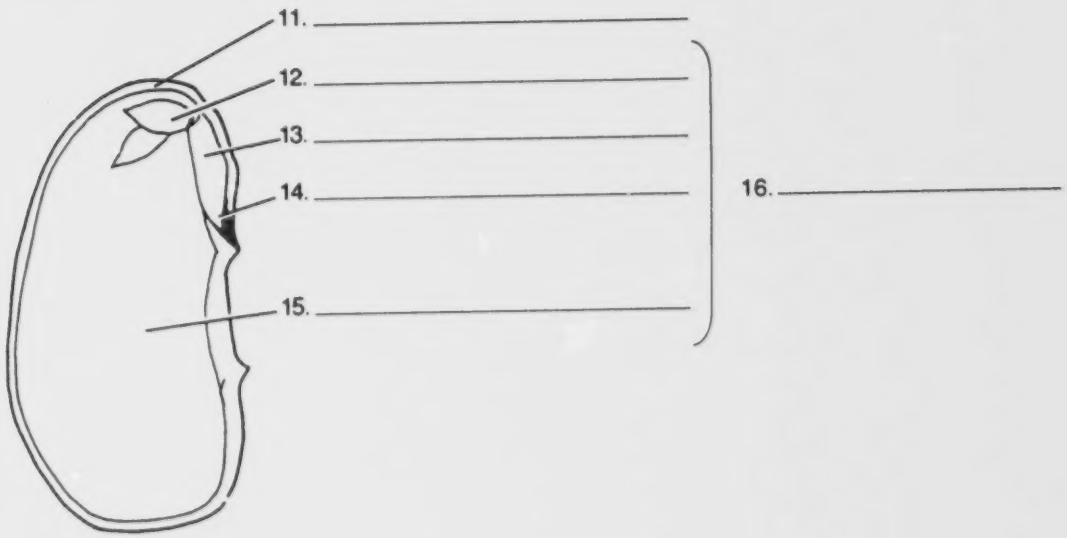


Identify the following parts:

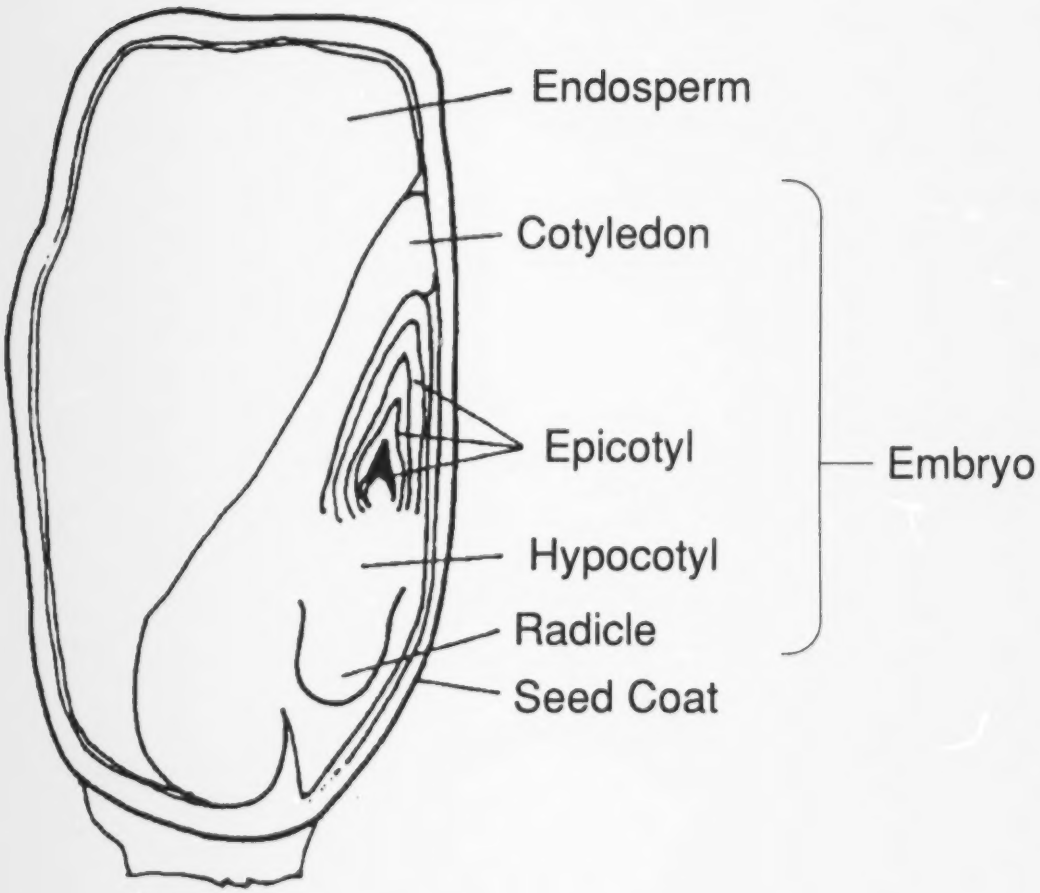
Dicot Seed (Bean)

Parts

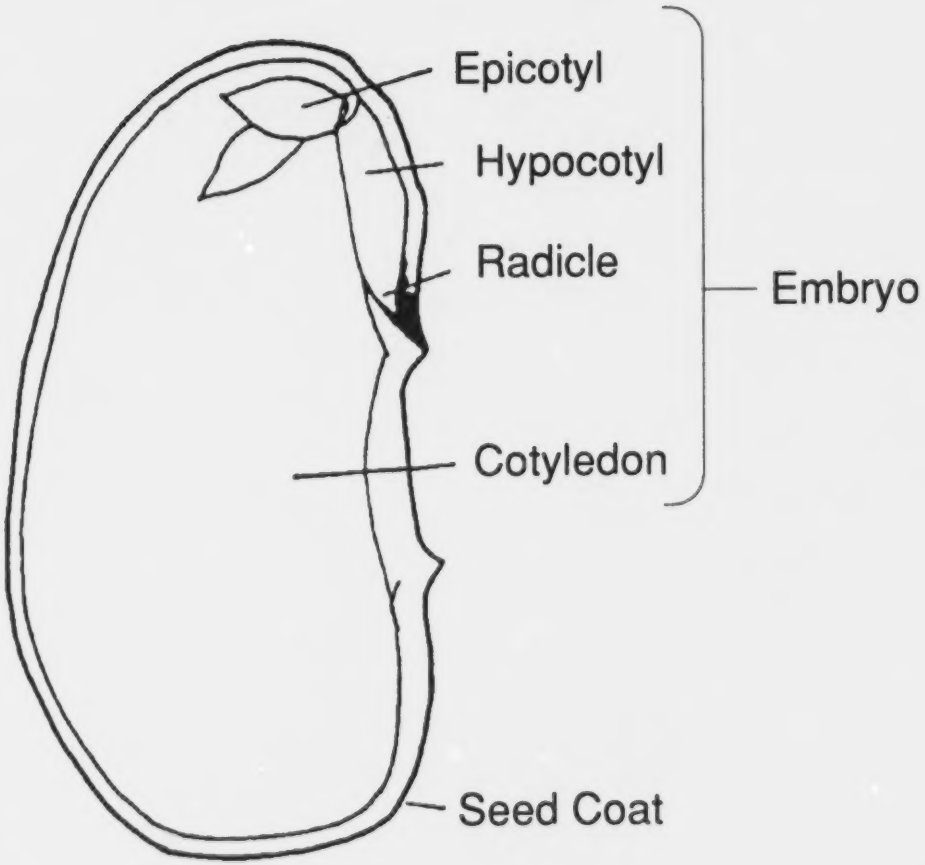
Seed coat
Hypocotyl
Cotyledon
Radicle
Epicotyl
Embryo



Monocot Seed (Corn) and Its Parts

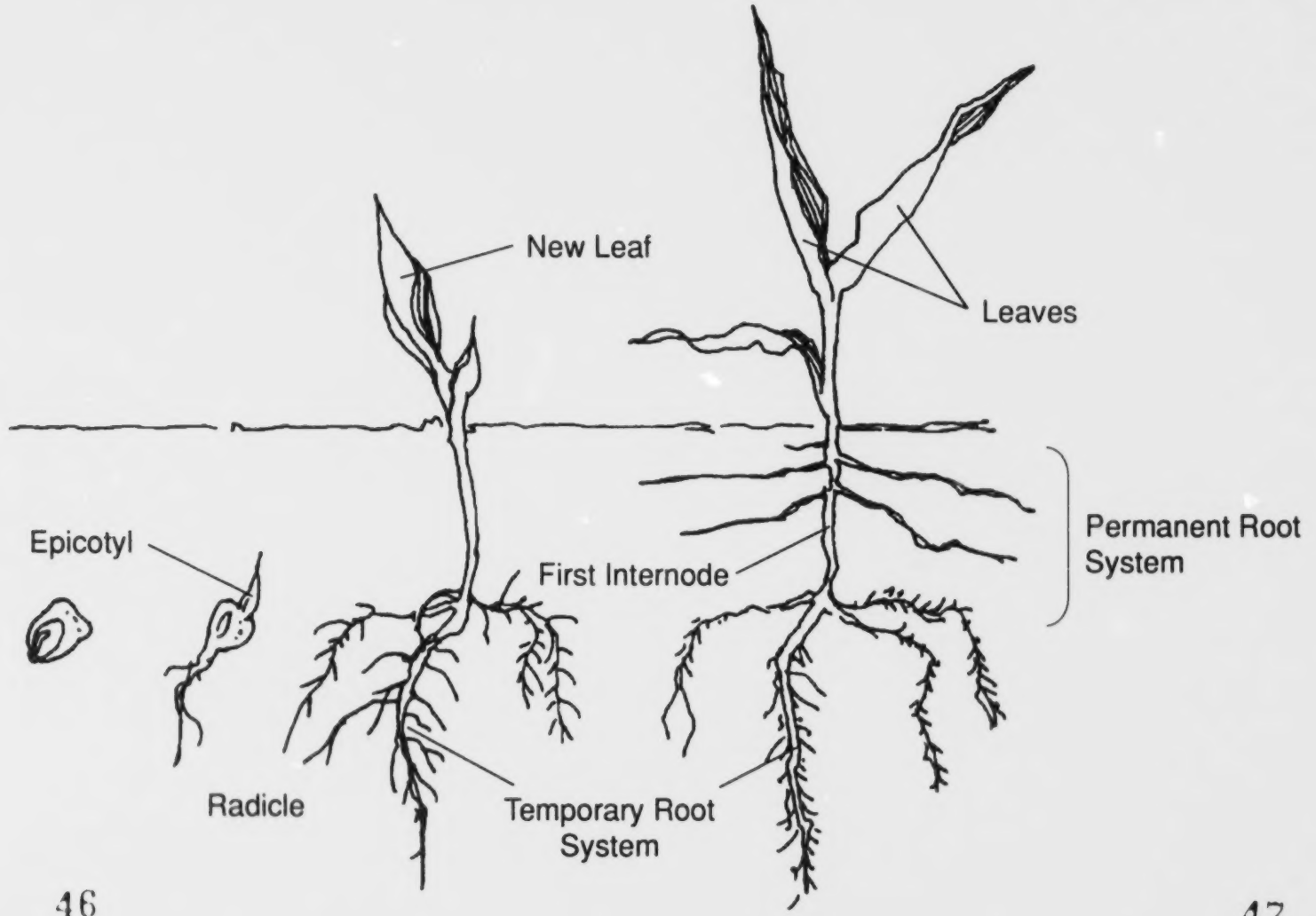


Dicot Seed (Bean) and Its Parts

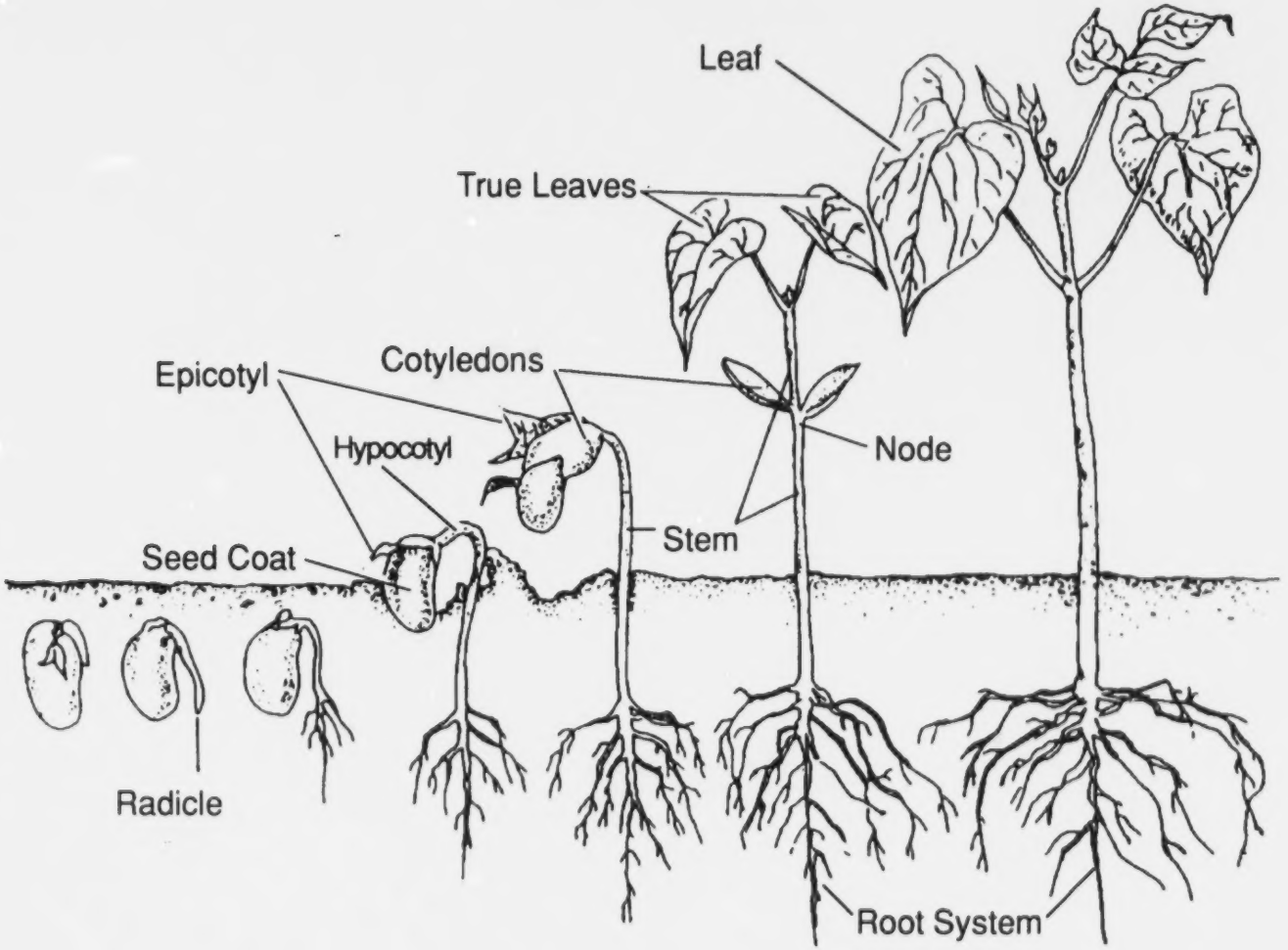


***This graphic illustrates only one-half of the dicot seed.**

Stages in Germination and Emergence of a Monocot Seed (Corn)



Stages in Germination and Emergence of a Dicot Seed (Bean)



UNIT - PLANT SCIENCE

Lesson 6: Photosynthesis and Respiration

Objective: The student will be able to describe basic plant processes.

Study Questions

1. **What are the five basic plant processes?**
2. **How are nutrients and water moved through a plant?**
3. **How do plants manufacture food?**
4. **How do plants use food that they manufacture?**
5. **What role do plants play in improving air quality?**

References

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.
2. Movies from the Academic Support Center Film Library, University of Missouri-Columbia.
   a) Photosynthesis
   b) Photosynthesis and the Respiration Cycle
   c) Plants Make Food
   d) Role of the Green Plants

UNIT - PLANT SCIENCE

Lesson 6: Photosynthesis and Respiration

TEACHING PROCEDURES

A. Review

Review Lesson 5. Describe how monocot and dicot seeds differ. Review the process of germination.

B. Motivation

Using a white carnation, cut off the tip of the stem (1/4" to 3/8") and place it down in a jar of water that has been colored with red or blue food coloring. This can also be done with a stalk of celery. Discuss with the class just what the plant is doing while the solution is being drawn up into the plant material. Use this to lead into lesson.

C. Assignment

D. Supervised study

E. Discussion

1. Proper plant growth is directly related to five basic processes that occur in plants.

What are the five basic plant processes?

a) Photosynthesis
b) Respiration
c) Water absorption
d) Translocation
e) Transpiration

2. Plants require nutrients for proper growth and development. In order for the nutrients to benefit the plant, they must be distributed throughout the plant. The movement of nutrients and water in a plant involves three processes: transportation, translocation, and absorption.

How are nutrients and water moved through a plant?

a) Transpiration - loss of water by evaporation through the leaf surface; causes tension on the xylem tissues, which triggers the hair roots to absorb more water
b) Translocation - movement of water and organic compounds within the plant
   1) Xylem tissues transport water and dissolved minerals upward from the roots.
   2) Phloem tissues transport compounds from the leaves to the rest of the plant.
c) Absorption - water and dissolved minerals are absorbed by plant root hairs through the process of osmosis

3. Every living organism needs food to produce energy so essential activities within the cells can take place.

How do plants manufacture food?

Through the process of photosynthesis, green plants convert carbon dioxide and water in the presence of light into simple sugar (food).

$$6\,CO_2 + 6\,H_2O \xrightarrow[\text{light energy}]{\text{chlorophyll}} C_6H_{12}O_6 + 6\,O_2$$

(carbon dioxide) (water) (glucose) (oxygen)

4. Energy from the sun enables plants to produce food through the process of photosynthesis.

How do plants use food that they manufacture?

a) To produce the energy necessary to perform various plant processes
b) To build new plant tissue resulting in plant growth
c) To store food in the form of carbohydrate substances
d) Respiration - uses energy to release carbon dioxide (CO_2) and water (H_2O) into the atmosphere.

5. Air (oxygen) is important to sustain animal life. Plants improve air quality through the process of photosynthesis.

What role do plants play in improving air quality?

Plants produce oxygen as a by-product of photosynthesis and they use carbon dioxide from the air.

F. Other activities

View one or more of the following films available from the Academic Support Center Film Library at the University of Missouri-Columbia.

1. "Photosynthesis"
2. "Photosynthesis and the Respiration Cycle"
3. "Plants Make Food"
4. "Role of the Green Plants"

G. Conclusion

The five basic plant processes needed for proper plant growth and development are respiration, photosynthesis, water absorption, translocation, and transpiration. Plants play a vital role in improving air quality by producing oxygen as a by-product of photosynthesis.

H. Competency

Describe basic plant processes.

I. Answers to Evaluation

1. c
2. d

3. a
4. b
5. e
6. c
7. d
8. c

UNIT - PLANT SCIENCE Name _____

Lesson 6: Photosynthesis and Respiration Date _____

EVALUATION

Correctly match the appropriate plant process with the description of that process.

_____1. The process through which water containing dissolved minerals enters the plant's hair roots

_____2. The movement of water and organic materials within the plant

_____3. The process through which green plants convert carbon dioxide and water in the presence of light into simple sugar (food)

_____4. The breakdown of glucose, releasing energy for plant growth, and other metabolic processes or chemical reactions occurring within the cell

_____5. The loss of water by evaporation primarily from the leaf surface

a. Photosynthesis
b. Respiration
c. Water absorption
d. Translocation
e. Transpiration

Circle the letter that corresponds to the best answer.

6. In the process of manufacturing food, plants require water, light energy and ____.

   a. Oxygen
   b. Glucose
   c. Carbon dioxide
   d. Energy

7. Respiration produces carbon dioxide, water, and ____.

   a. Oxygen
   b. Glucose
   c. Carbon dioxide
   d. Energy

8. Plants contribute to air quality because they ____.

   a. Provide a source of carbohydrates to humans
   b. Use light energy to produce food
   c. Produce oxygen as a by-product
   d. Have chlorophyll in their cells

UNIT - PLANT SCIENCE

Lesson 7: Reproduction - Sexual and Asexual

Objective: The student will be able to describe how plants reproduce sexually and asexually.

Study Questions

1. **What is the difference between sexual and asexual propagation?**
2. **What is a flower?**
3. **What are the parts of complete and incomplete flowers?**
4. **What is involved in pollination and fertilization?**
5. **What conditions can influence pollination and fertilization?**
6. **What plant parts may be used for asexual propagation?**
7. **What are the methods of asexual propagation?**

References

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.
2. Transparency Master
   a) TM 7.1: Flower Parts

UNIT - PLANT SCIENCE

Lesson 7: Reproduction - Sexual and Asexual

TEACHING PROCEDURES

A. Review

Discuss the five basic plant processes presented in Lesson 6: photosynthesis, respiration, water absorption, translocation, and transpiration.

B. Motivation

Before class, prepare two germination trays (flats) with soil (or growing medium) in them. Purchase a package of seeds (select a fast germinating flowering annual) and a potted geranium plant. In front of the class, cut up the geranium plant and place the pieces in one flat. Place the seeds in the other flat. Ask students what they think you did. Relate this demonstration to the topic.

C. Assignment

D. Supervised study

E. Discussion

1. The process of a plant reproducing another plant is called reproduction. The controlled reproduction of plants is called plant propagation. Plant propagation can be accomplished either by sexual or asexual means. Some plants can only reproduce by sexual means. Others will only reproduce by asexual means. Still others can be propagated by either sexual or asexual methods.

   What is the difference between sexual and asexual propagation?

   a) Sexual plant propagation uses seeds to produce new plants.
   b) Asexual plant propagation involves the use of a vegetative part of the plant to produce another plant.

2. Flowers vary depending on the type of plant. Some flowers are very bright and colorful while other flowers are quite small and almost unnoticeable. Use TM 7.1 to identify the parts described below.

   What is a flower?

   The flower is the sexual reproductive part of a plant. A complete flower contains four parts.
   a) Sepals - the outer, scale-like covering around the flower bud
      1) All of the sepals together are called the calyx.
      2) The function of the sepals is to protect the petals, stamens, and pistils when the flower is in the bud stage.
   b) Petals - usually brightly colored to attract pollinators (usually insects)
      1) All of the petals together are called the corolla.
      2) The petals protect the stamens and pistils in the bud stage.
   c) Stamens - the male reproductive part (Each stamen consists of two parts: the anther and the filament.)
      1) The anther produces pollen grains.

2) The filament supports the anther.

d) Pistil - the female reproductive part (The pistil consists of the ovary, stigma, and style.)
   1) The ovary is the enlarged portion at the base of the pistil. The function of the ovary is to produce ovules. Ovules that are fertilized become seeds.
   2) The stigma receives and holds the pollen grains.
   3) The style connects the stigma with the ovary. Pollen grains travel through the style to reach the ovary. The style supports the stigma.

3. Plants produce flowers as part of their life cycle. Some plants produce complete flowers while other plants produce incomplete flowers. Refer to TM 7.1.

What are the parts of complete and incomplete flowers?

a) A complete flower contains all four main parts of a flower: sepals, petals, stamens, and pistils.
b) An incomplete flower is missing one or more of the main parts of the flower.

4. Sexual plant reproduction involves pollination and fertilization.

What is involved in pollination and fertilization?

a) Pollination is the transfer of pollen from the anther to the stigma.
b) Fertilization is the union of male and female cells to form the first embryonic cell.

5. Plants require proper environmental conditions for sexual reproduction to take place.

What conditions can influence pollination and fertilization?

a) Favorable weather conditions
b) Wind
c) Pollinators (insects, birds)

6. Asexual plant reproduction involves using parts of a plant to produce a new plant without seed.

What plant parts may be used for asexual propagation?

a) Stems
b) Leaves
c) Roots

7. There are several methods of asexual propagation and the choice of method depends on the plant and the desired objectives of the propagator.

What are the methods of asexual propagation?

a) Cuttings - a piece cut from the parent plant and rooted
b) Division - separating clumps of plants into smaller groups
c) Layering - rooting a new plant part while it is still attached to the parent plant
d) Grafting - inserting buds, twigs or shoots from one plant onto the stem of another plant
e) Budding - inserting a bud(s) of one plant into the bark of another variety
f) Tissue culture - using a single cell or a small piece of plant tissue (explant) to produce a new plant

F. Other activities

1. Instructor can bring to class a selection of flowers for students to dissect, locate, and label parts. Hibiscus is excellent for this activity.

2. Instructor can provide the opportunity for students to do several methods of asexual propagation: grafting, air-layering, leaf cutting, etc.

G. Conclusion

Plant reproduction can occur in two ways. Sexual reproduction involves the production of seed through the union of two specific cells. The seeds are then used to start new plants. Asexual propagation involves the use of selected plant parts to develop a new plant.

H. Competency

Describe how plants reproduce sexually and asexually.

I. Answers to Evaluation

1. False
2. True
3. True
4. True
5. Stamen
6. Anther
7. Filament
8. Sepal
9. Petal
10. Stigma
11. Style
12. Ovary
13. Pistil
14. c
15. b
16. a
17. e
18. f
19. d

UNIT - PLANT SCIENCE Name _____

Lesson 7: Reproduction - Sexual and Asexual Date _____

EVALUATION

True/False (Place the correct response in the blank provided.)

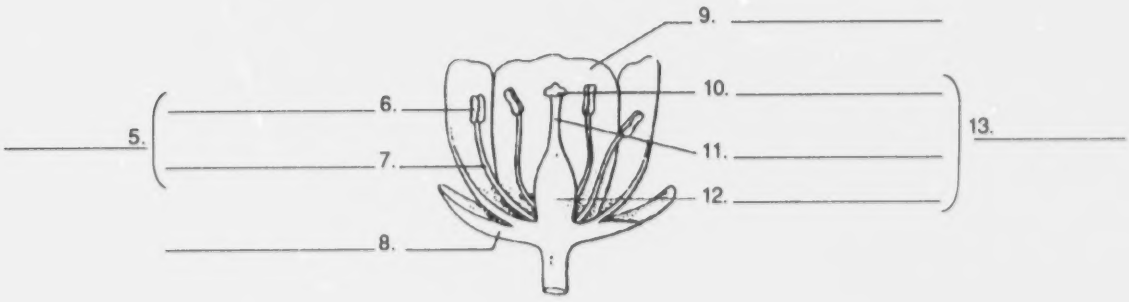
____ 1. Sexual plant reproduction involves the use of vegetative plant parts to produce another plant.

____ 2. Asexual plant reproduction involves the use of plant parts to produce another plant.

____ 3. Pollination and fertilization are part of sexual plant reproduction.

____ 4. Complete flowers contain the pistil.

Identify the parts of the flower.



Match the correct method with its description.

____ 14. Plant pieces that are cut from the parent plant and rooted to form new plants

____ 15. Separating clumps of plants into small groups

____ 16. Rooting a new plant while the stem is still attached to the parent plant

____ 17. Method of inserting buds, twigs, or shoots from one plant onto the stem of another plant

____ 18. The production of another plant from a meristematic tissue cell

____ 19. Inserting a single bud into the bark of another variety

a. Layering

b. Division

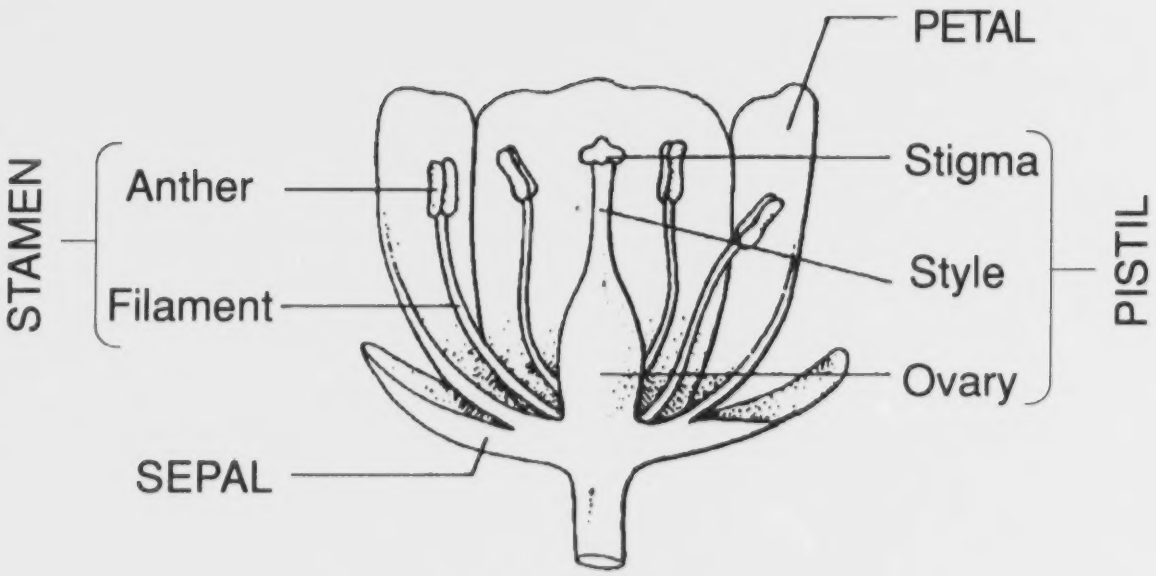
c. Cuttings

d. Budding

e. Grafting

f. Tissue culture

Parts of a Complete Flower



UNIT - PLANT SCIENCE

Lesson 8: Plant Genetics

Objective: The student will be able to describe how genetics influences plant growth.

Study Questions

1. **What is meant by the term inheritance?**
2. **How does genetics influence plant growth?**
3. **What is a gene?**
4. **Why is DNA important?**
5. **What is genetic engineering?**
6. **How does crop production benefit from biotechnology?**
7. **What are some ethical considerations in genetic engineering?**

Reference

1. Plant Science (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1991.

UNIT - PLANT SCIENCE

Lesson 8: Plant Genetics

TEACHING PROCEDURES

A. Review

Review the methods of plant propagation from the previous lesson. Tie in reproduction to plant genetics and biotechnology. Biotechnology is not new. Researchers and scientists have been working with biotechnology since the 1950s. However, discoveries made within the last 20 years in the area of genetics have opened the door to greater possibilities in producing quality agricultural products for an ever growing world population.

B. Motivation

Using a large world map in front of the class, point out every body of water that is considered salt water. Then explain how some plants can survive salt water while most cannot. Easter lilies, for example, are fairly salt tolerant. Ask students what benefit it would be if other plants (e.g., corn and wheat) could be grown using salt water for irrigation. Ask students if plants could be produced that were not hurt by salt water, how would this affect world food production.

C. Assignment

D. Supervised study

E. Discussion

1. Children inherit specific characteristics such as hair and eye color from their parents. Plants also inherit characteristics from parent plants.

   What is meant by the term inheritance?

   Inheritance is the transmission of genes (i.e., traits, characteristics) from one generation to the next.

2. Research conducted in the area of inheritance of specific traits involves the study of genetics (the biology of heredity). Researchers have begun to manipulate the genetic makeup of plants to develop improved varieties.

   How does genetics influence plant growth?

   The genetic makeup of a plant determines the expression of traits (e.g., yield potential, flower color, size of plant, resistance to disease).

3. The nucleus of each plant cell contains chromosomes. Chromosomes are a sequence of DNA (deoxyribonucleic acid) molecules which contain genetic information (genes).

   What is a gene?

   Genes are the parts of a chromosome that determine the individual plant characteristics. (the smallest unit of inheritance)

4. Each plant species has specific characteristics. These characteristics are directly related to the plant's DNA (deoxyribonucleic acid).

Why is DNA important?

a) It serves as the coding mechanism for heredity (genes).
b) It contains information to control the synthesis of enzymes and other proteins that control the basic metabolic processes of all cells.

5. Research in plant genetics provides a clearer understanding of the transmission of specific characteristics. These characteristics can be altered through the process of genetic engineering.

What is genetic engineering?

Genetic engineering is the process of transferring genes from one organism to another.

6. Discuss with the class what biotechnology means and what biotechnology has done in the area of crop production.

How does crop production benefit from biotechnology?

a) Increase of production levels (yield)
b) New plant development (somatic hybrids)
c) Possible increase of specific beneficial characteristics (salt tolerance, disease resistance, etc.)

7. Public perception about biotechnology and the use of genetic engineering may be a result of a combination of factors. The average U.S. citizen may not understand all the scientific terminology, but they still desire to be informed as to what the scientific community is doing.

What are some ethical considerations in genetic engineering?

a) Motives for research
b) Safety
c) Application of findings
d) Social and consumer acceptability
e) Environmental impact
f) Costs versus benefits

F. Other activities

1. Have students do written reports in the area of genes, DNA, genetic engineering related to plants, and how research in this area has benefitted the world's population.

2. Take a field trip to Monsanto in St. Louis or another agribusiness that is involved with biotechnology.

3. Have students read and report on magazine or newspaper articles on genetic engineering.

G. Conclusion

Plant genetics involves many areas of research. Studies on the inheritance of traits, DNA, genes, and genetic engineering continue to open new doors into the plant world to provide better ways to produce food for a growing world population.

H. Competency

Describe how genetics influences plant growth.

I. Answers to Evaluation

1. b
2. c
3. a
4. d
5. a
6. c

UNIT - PLANT SCIENCE Name _____

Lesson 8: Plant Genetics Date _____

EVALUATION

Circle the letter that corresponds to the best answer.

1. The transmission of characteristics from one generation to another is referred to as _____.

   a. Plant growth
   b. Inheritance
   c. Reproduction
   d. Genetics

2. The part of a chromosome that determines individual plant characteristics is called _____.

   a. Trait
   b. Pollen
   c. Gene
   d. Enzyme

3. Which of the following contains information that controls the metabolic processes of a plant cell?

   a. DNA
   b. Characteristic
   c. Inheritance
   d. Enzyme activity

4. Somatic hybrid plants are produced through _____.

   a. Self-pollination
   b. Sexual reproduction
   c. Enzyme activity
   d. Genetic engineering

5. The genetic information that is passed from generation to generation is found in _____.

   a. DNA
   b. Characteristics
   c. Pollination
   d. Genetic engineering

6. The manipulation of specific characteristics of a plant is known as _____.

   a. Metabolic activity
   b. Enzyme activity
   c. Genetic engineering
   d. Chromosomes

MISSOURI AGRICULTURAL EDUCATION

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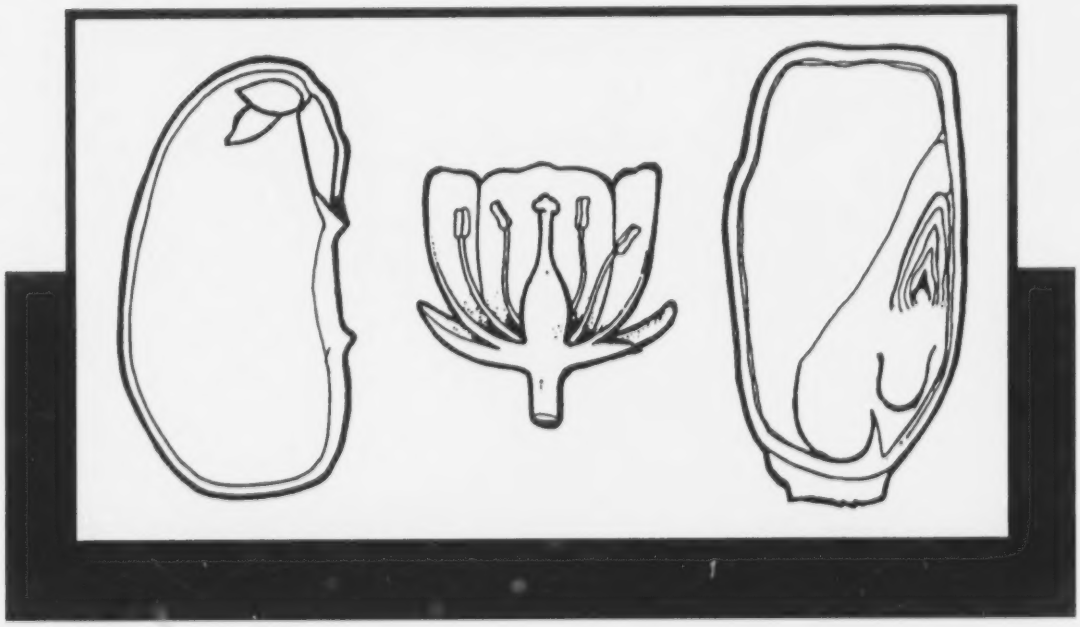
Student Reference

Plant Science



In cooperation with Agricultural Education
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Vocational-Technical Education
College of Education and
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The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

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Volume 24
Number 4

Catalog Number 10-1005-S
November 1991

ACKNOWLEDGMENTS

Recognition is given to advisory committee members for providing their valuable time and suggestions in developing this plant science unit. The committee consisted of Matt Biddle, Bob Buehler, Dan Forster, Steven King, Delbert Lund, Richard Mattas, Bob McGraw, Charles Parkes, Bill Roberts, Brenda Smith, and Jim Welker.

Appreciation is expressed to the following staff members of the Instructional Materials Laboratory for their efforts in producing this material: Harley Schlichting, Director; Amon Herd, Associate Director; Phyllis Miller, Assistant Director; Dan Stapleton, Assistant Director; Sharon Dyer, Graphic Designer; Lori Holliday and Tracy Stock, Word Processors; and Wei Li, Graduate Assistant.

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FOREWORD

The revision of the Plant Science unit is the result of suggestions by the MVATA Teaching Aids Committee. The Plant and Crop Science Advisory Committee suggested the topics to be included and reviewed the materials.

This student reference contains eight lessons: Importance of Plants; Classification of Plants; Plant Growth Factors; Weeds, Diseases, Insects; Germination; Photosynthesis and Respiration; Reproduction - Sexual and Asexual; and Plant Genetics. See the Table of Contents for a detailed listing of topics.

Persons using this reference on an individual basis may wish to purchase the instructor's guide, which contains additional reference materials.

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UNIT - PLANT SCIENCE

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Lesson 1:
Importance of Plants

Plants and their role in the survival of humans and animals on this planet are irreplaceable. Plants provide food, shelter, clothing, and a variety of other benefits. People will always need what plants provide; however, most plants can survive without people. Research and study continue to reveal new discoveries and uses of plants. Technology continues to make possible the means by which the growing demands for food and fiber from plant sources can be met.

The Importance of Plants

Plants play an important part in the food chain. Many animals depend on plants for their survival. Since the earliest recorded history, ancient civilizations have been concerned with providing food for their people. Plants have always played a major role in providing food.

As the human population increased, hunting and gathering could no longer provide enough food. Agricultural practices that involved large scale production of food crops such as corn, wheat, oats, barley, and rice enabled farmers to provide enough food for humans and livestock.

Nonfood products can also come from plants. Fiber crops provide many needed products. Cotton, hemp, flax, jute, and sisal are all fiber crop species, with cotton being the most widely grown. Production of fiber crops provides the raw materials needed to produce products like clothing, bedding, rope and cords along with other textiles.

Most plants can survive without any assistance from humans. However, people cannot survive without plants. Aside from the production of food and fiber crops, plants provide much more. Plants and the processes involved with plant growth are beneficial to the environment.

The Environment

Plants play a major role in the environment. All forms of life need energy for growth and maintenance. Plants, algae, and some bacteria are able to take energy from the sun and convert it into food. This process is known as photosynthesis. Life forms that are unable to obtain energy through photosynthesis must eat plants or other animals that eat plants in order to get their energy.

During the process of photosynthesis, plants absorb water from the soil and carbon dioxide from the air. Water and carbon dioxide combine with energy from the sun to produce carbohydrates (food) for the plant. This process produces oxygen. Without oxygen, people cannot live. Plants provide some of the food humans eat and the oxygen they breathe.

Besides using carbon dioxide, plants act as holding organisms for carbon dioxide (carbon sinks). Carbon sinks are extremely beneficial to humans. Carbon dioxide is a natural component in the environment. A problem arises when natural carbon dioxide levels are increased by exhaust from industries and automobiles and when plants are destroyed. The removal of trees and underbrush creates an imbalance in the environment. Care must be taken when altering the balance of these natural processes.

Soil erosion is another problem that plants can reduce or prevent. Trees, bushes, and grasses help break the force of pounding rains, fast moving surface water, and damaging winds. Soil is a precious natural resource that must be conserved. Certain agricultural methods in crop production, such as leaving crop residues (corn stalks or wheat stubble) on the field, helps to prevent soil erosion. These crop residues and grasses can be turned into the soil to increase the organic content and quality of the soil.

Another major role of plants in the environment is beautification. People spend millions of dollars on beautifying homes, cities, businesses, towns, interstates, restaurants, etc. Cut flowers, houseplants, indoor trees, gardens, etc., provide a more pleasing environment. Plants can change the environment. They can be used as sound barriers (block out traffic noise) or visual barriers (block off an unappealing view). Grasses can be used for recreational areas such as football and softball fields.

Crops and Origins

There are many food and fiber crops grown in the U.S., but very few are native to this country. Of all the food crops grown in the U.S., corn is the only crop native to North America. Corn was introduced to the Pilgrims by the Native American Indians; however, it is believed to have originated in southern Mexico.

There are many stories about how the different food crop species were introduced to the North American continent. Table 1.1 helps identify some common crop plant species grown in the U.S., the time period when they were introduced, their origin, and their uses.

Table 1.1 - Crop Orgin

Crop	Introduced into the U.S.	Origin	Crop Use
Barley	Pilgrims	Abyssinia & Southeastern Asia	Food, feed
Corn	A.D. 700	Mexico	Food, feed, oil, alcohol, industry products
Wheat	Shortly after the discovery of America by Columbus	Southwestern Asia, Euphrates & Tigris Valleys	Food, feed
Oats	Shortly after the discovery of America by Columbus	Eastern Europe or Western Asia	Food, feed
Rice	1964-South Carolina	Southeast Asia	Food, some oil, industrial use
Peanuts	Early days of Colonization	Brazil	Food, oil, feed
Potatoes	Between 1705-1749	South America	Mainly food, some feed
Sorghums	Early days of Colonization	Africa and India	Sugars, feed, industrial uses
Cotton	Actual date not known - found on the Continent when discovered by Columbus	Mexico and India	Fibers, oil from seeds, feed, food from seed
Flax	1800s	Mesopotamia, Assyria, Egypt	Oil, feed, industrial uses
Soybeans	During early colonial period	China	Food, feed, oil
Alfalfa	Introduced into what is now known as Mexico by the Spanish in the 1500s. Introduced into California in the early 1840s.	Different alfalfa plant species come from different places (e.g., Russia, Indica)	Forage crop for feed

Uses

Plants are used in a variety of ways. One obvious use is in the production of food and fiber crops. Researchers also use plants. Biotechnology (genetic manipulation) is used to produce genetically superior plants. Crossbreeding is also used to produce hybrid varieties of plants with specific desirable qualities. If a disease or pest-resistant plant species is needed for a certain location in the world, biotechnology or crossbreeding can be used to develop such a variety.

Plants are also used in the production of nonfood products. Examples of nonfood products include medicines, clothing, rubber, perfumes, and spices. Even though scientists continue to work on developing synthetic products, plants continue to be the primary producers. Plants are also used for beautification in lawns, parks, etc.

Summary

Plants and plant products provide many things for the world. They provide food, fibers, and oxygen. Humans cannot survive without plants.

Credits

Bishop, D.D.; S.R. Chapman; L.P. Carter. Working In Plant Science. New York, NY: McGraw-Hill, 1978.

Janick, Jules; Robert W. Schery; Frank W. Woods; Vernon W. Ruttan. Plant Science: An Introduction To World Crops. 2nd ed. San Francisco: W.H. Freeman and Company, 1974.

Lesson 2:
Classification of Plants

Continued study and research have increased our knowledge of plants. There are over 500,000 different plant species. A method of classification is needed to help researchers identify different species. This lesson is about methods of plant classification. By classifying plants, a better understanding of the plant world can be achieved.

Classification

Since as far back as recorded history, humans have depended on plants for food and shelter. Plants have been studied, and crude methods of classification were developed. The crude means by which plants were grouped together was successful until the world population grew and became inhabited by people of many languages. A method of classification was needed that could cross cultural and language barriers.

In 1753, Carolus Linnaeus, a Swedish naturalist and botanist, established the method of classifying plants that is used today. The Linnaeus method of classifying plants divided each plant's name into two parts. The first part is for the genus (group); the second part is for the species (kind). Linnaeus was a botanist, which is a person who specializes in the study of plants. The method used by Linnaeus and botanists today is referred to as the botanical method of classification. This method classifies plants regardless of their agricultural importance. The genus and species names given to plants are usually of Latin origin.

Another method of classification is known as descriptive classification. Descriptive classification is used mostly by plant scientists, agronomists, and farmers. This method deals mainly with crop plants. This classification is descriptive of the plant's use by humans rather than its botanical classification. Descriptive classification can help identify plants' cultural needs, growth patterns, limitations, and requirements for optimum production or growth.

Botanical Classification

As research and study of plants increased throughout history, the need to share discoveries became more apparent. For example, scientists working in Germany needed to share their findings with scientists in South America working on the same problem; therefore, the language barrier needed to be solved. As early as the Middle Ages, Latin was the recognized language used throughout the world by scholars and educated individuals. Latin was the basis of most European languages, including English. It was taught throughout the world regardless of a country's native tongue. Since Latin is considered an unchanging language, it is suitable for universal communication. Therefore, botanical classification uses Latin to identify the genus and species of plants.

Botanical classification places plants into discrete categories called taxa (plural for taxon). The naming of organisms is termed nomenclature, and the grouping of organisms is termed classification. These two processes belong to a specialized field known as taxonomy. Taxonomists are scientists who classify and name plants.

The botanical classification system is important because it clearly identifies plant species. Botanical classification attempts to group plants according to their similarities. In the botanical system, there are eight levels of classification for each species. The "kingdom" is the broadest category of classification. The "species" is the most specific category. Using the acronym "KDCSOFGS" may help people remember the levels of the classification system.

1. Kingdom
2. Division or phylum
3. Class
4. Subclass
5. Order
6. Family
7. Genus
8. Species

Each of the eight levels is used to classify an individual plant species. Botanical classification also helps to identify how plant species differ from other plants. Table 2.1 is an example of botanical classification.

Table 2.1 - Wheat versus Barley Classification

	Wheat	Barley
1. Kingdom	Plantae (plant, distinct from animal)	Plantae (plant, distinct from animal)
2. Division	Spermatophyta (or seed plants)	Spermatophyta (or seed plants)
3. Class	Angiosperma (or plants with their seeds in a fruit)	Angiosperma (or plants with their seeds in a fruit)
4. Subclass	Monocotyledonae (seed with single seed leaf)	Monocotyledonae (seed with single seed leaf)
5. Order	Graminales (grass-like families)	Graminales (grass-like families)
6. Family	Graminae or Graminaceae (the grasses)	Graminae or Graminaceae (the grasses)
7. Genus	Triticum (the wheats)	Hordeum (the barleys)
8. Species	aestinum (bread wheat)	vulgare (barley)

By comparing the two species, one can see the similarities between the two species from kingdom to family. However, the two plants differ at the genus and species levels. This system is used to correctly identify specific species, especially when there are several different species in a particular genus.

Monocots and Dicots

Agricultural plants can be divided into monocotyledonous plants and dicotyledonous plants. Monocotyledonous plants, frequently called monocots, have seeds with a single cotyledon (first leaf). (See Figure 2.1.)

Dicotyledonous plants, which are frequently called dicots, have seeds with two cotyledons (first leaves). The differences in these two major classes of plants can be clearly seen by comparing their seeds, root systems, stems, leaves, and flowers. Seeds of monocots contain the embryo, endosperm, and one cotyledon. (Figure 2.2)

Monocots have an embryonic root, which develops from the seed. This embryonic root dies soon after the seed germinates. The whole root system of monocots is composed of adventitious roots. Figure 2.3 shows the location of the adventitious roots of the monocots. Monocots have many roots that are all about the same size.

Figure 2.1 - First Leaves of Monocots and Dicots

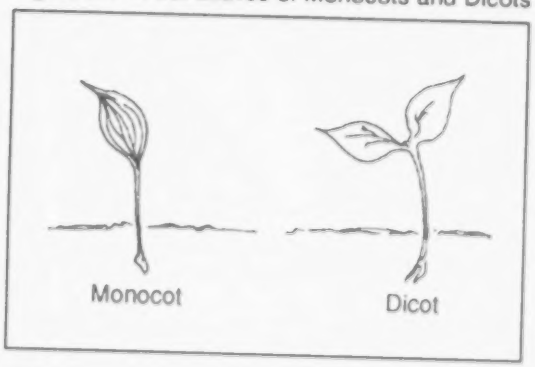


Figure 2.2 - Monocot Seed

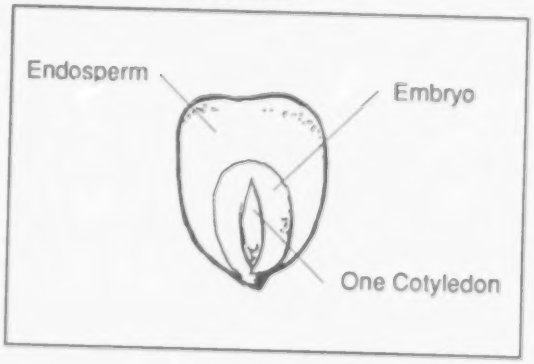
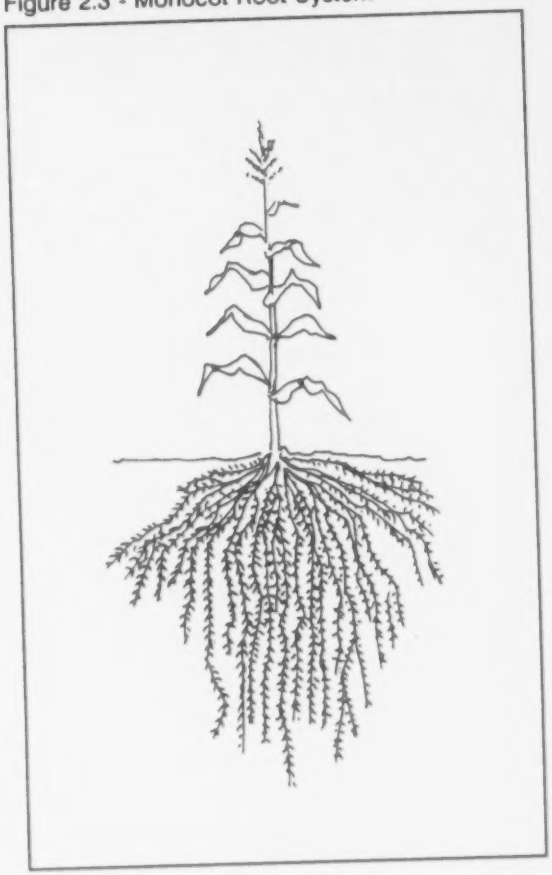


Figure 2.3 - Monocot Root System



Monocots usually have ten vascular bundles scattered throughout the stem. These vascular bundles contain xylem and phloem tissues, not vascular cambium tissues. See Figure 2.4.

Figure 2.4 - Monocot Stem

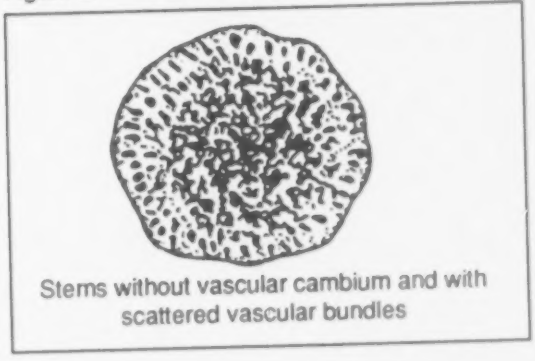
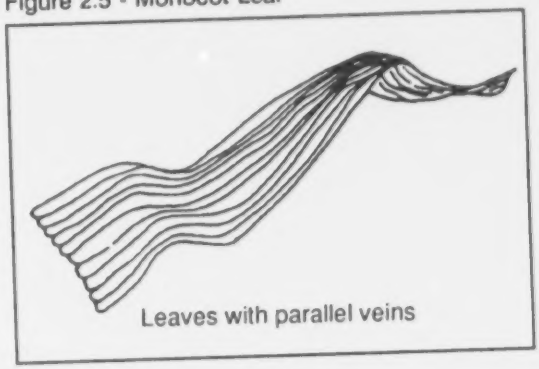
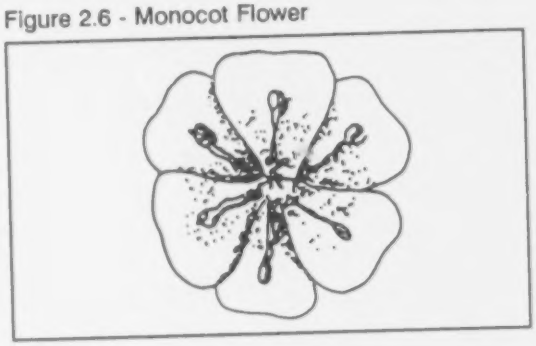


Figure 2.5 - Monocot Leaf



Monocot leaves are long and narrow with parallel veins. In the leaf's epidermis, the cells are long and run in the same direction as the leaf length. See Figure 2.5.

Figure 2.6 - Monocot Flower



The flower of monocots contains three parts or multiples of three. See Figure 2.6.

Seeds of dicots contain an embryo, seed coat, and two cotyledons. See Figure 2.7.

Figure 2.7 - Dicot Seed

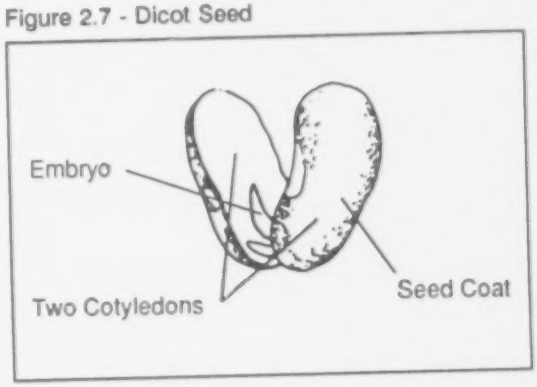
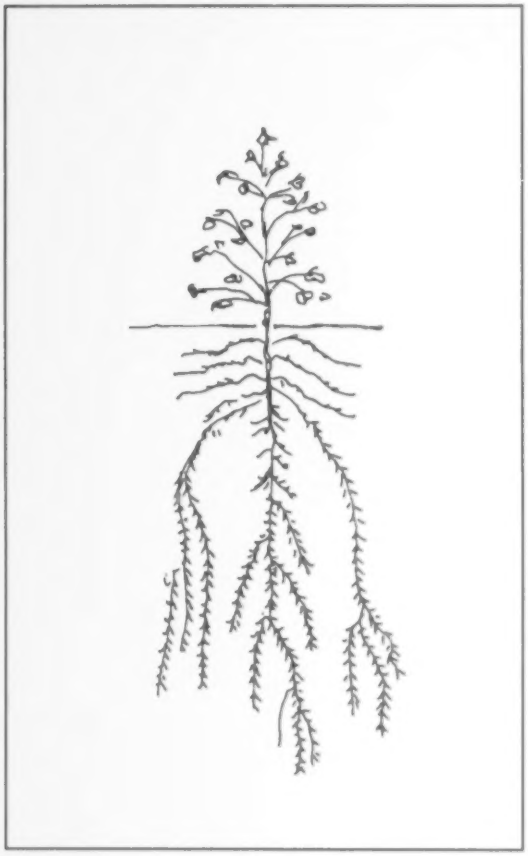


Figure 2.8 - Dicot Root System



Dicots have roots with numerous root hairs that have a very short life span, often only a few days. As the plant continues to grow, new roots and root hairs grow on a continuous basis. The primary root will begin to thicken and develop secondary growth at about the same time as the stem. (Figure 2.8)

The stem of dicots contains four or five vascular bundles that form a ring around the outside of the stem. Each vascular bundle contains phloem, cambium, and xylem tissues. (See Figure 2.9.)

Unlike monocots, leaves of dicots have a network of veins. The veins in dicots do not run parallel with the length of the leaf. (See Figure 2.10.) The flower of dicots contains four or five parts or multiples of four or five. (See Figure 2.11.) Figure 2.12 provides a comparison of dicots and monocots.

Figure 2.9 - Dicot Stem

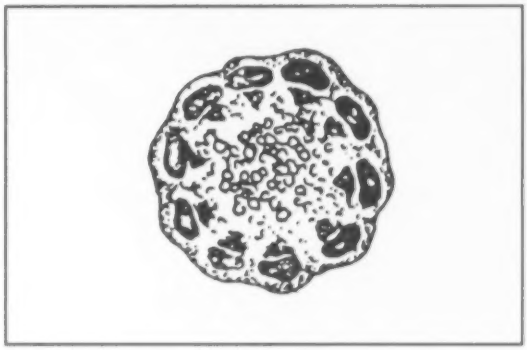


Figure 2.10 - Dicot Leaf

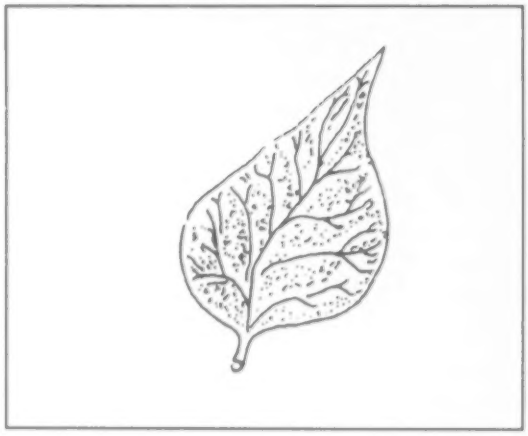


Figure 2.11 - Dicot Flower

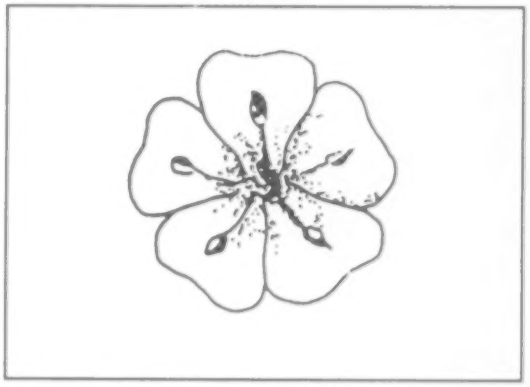
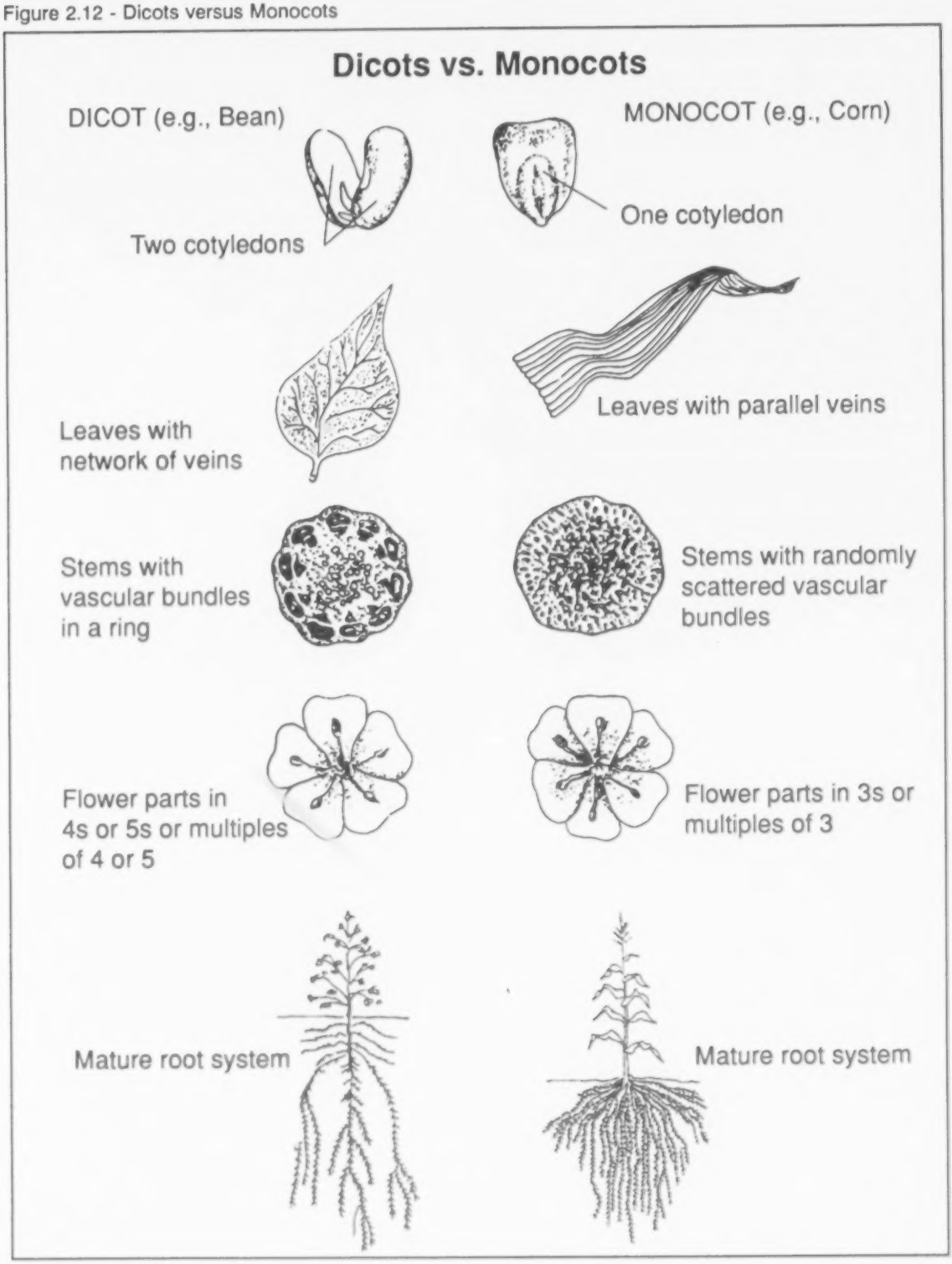


Figure 2.12 - Dicots versus Monocots


Dicots vs. Monocots
DICOT (e.g., Bean)
MONOCOT (e.g., Corn)
Two cotyledons
One cotyledon
Leaves with network of veins
Leaves with parallel veins
Stems with vascular bundles in a ring
Stems with randomly scattered vascular bundles
Flower parts in 4s or 5s or multiples of 4 or 5
Flower parts in 3s or multiples of 3
Mature root system
Mature root system

Legumes

Legumes (Leguminosae) are a unique family of plants in the plant kingdom. Legumes are named for the type of fruit, also called a pod, which is characteristic of plants in this family. Some examples of legumes are:

1. Soybeans
2. Peanuts
3. Beans: lentils, lima, black, black-eyed, kidney, pinto, white, scarlet runner, string, and shell
4. Peas: chick-pea and green pea

Legumes commonly used for livestock feed include:

1. Alfalfa
2. Clovers: red, white, alsike, and crimson; others less used: hop, Persian, sub, and strawberry
3. Birdsfoot trefoil
4. Vetch: common, hairy, purple, and Hungarian
5. Lespedeza: Korean, common, and perennial sericea

Legumes are also produced for their oil content. Some countries grow legume seeds primarily for their oil and use the protein as a by-product. For example, soybean oil is used in processed foods such as margarine, salad oils, and shortenings. Industrial oils from legume seeds are used in paints, varnishes, inks, and many other products.

Legumes are unique in their ability to obtain certain nutrients. All plants need nutrients for proper growth and development. The three primary nutrients needed are nitrogen, phosphorus, and potassium, all of which can be applied as fertilizers.

Some legumes have a unique capability known as symbiotic nitrogen fixation. They can take nitrogen from the air. Through a symbiotic relationship with rhizobia bacterium, legumes produce nitrogen in a form that plants can use.

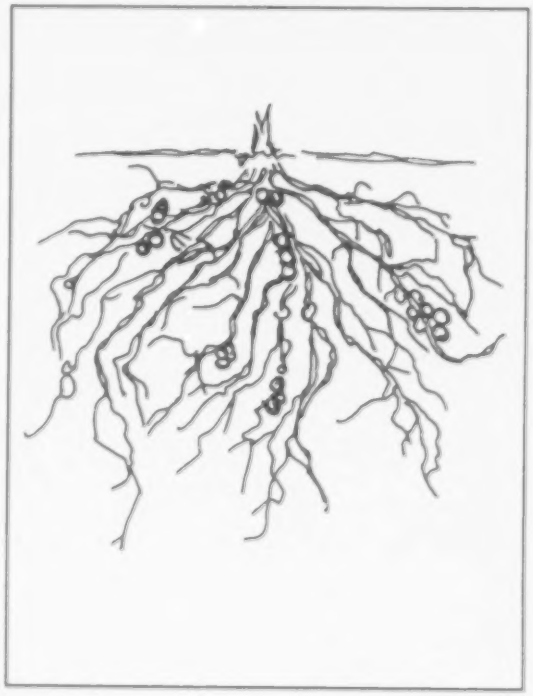
When the rhizobia bacterium enters the plant's roots, nodules form. These nodules work like small factories producing nitrogen that helps plants grow, thus reducing the need to apply commercial nitrogen fertilizers. This bacterium is not always naturally present in the soil. By placing a culture containing the bacterium on seeds before planting, it will increase the amount of nitrogen produced in the roots. Adding this bacterium to the seeds is called inoculation. (See Figure 2.13.)

In addition to reducing the need for nitrogen fertilizers, reducing cost, and increasing crop yields, nitrogen fixation enriches the soil. Some legumes are used as cover crops that are plowed into the soil. This increases soil nitrogen levels and benefits the next crop planted.

Life Cycles

Each plant grows in stages which, from beginning to end, are its life cycle. In descriptive classification, a plant's life cycle is important because it relates to the plant's productivity. The life cycle covers all stages of the plant's life from the seed through growth of the plant to the formation of another seed.

Figure 2.13 - Nodules on Legume Roots



Farmers and agricultural scientists study the life cycle of plants. This study increases the understanding of plants' reproductive cycles. Life cycles can be divided into three categories: annuals, biennials, and perennials. Annual plants complete their life cycles within one year or growing season. Many flowers purchased in the spring are annuals. They die off at the first frost and will not grow again the next year unless planted again.

Annuals can be subdivided into summer and winter annuals. Summer annuals are plants that are seeded in the spring and harvested in the fall. Corn is an example of a summer annual. A winter annual is a type of plant that is seeded in late summer or early fall and harvested the following summer. Winter wheat is an example of a winter annual.

Biennial plants require two years to complete their life cycles. Generally in the first year after planting, the plant produces mainly vegetative growth including leaves, stems, and roots. The second year the plant produces flowers, fruits, and seeds. At the end of the second year, the biennial dies. Sugar beets, carrots, and onions are examples of biennials.

Perennial plants live year after year. Perennials continue through their life cycle each year and produce flowers, fruits, and seeds. After they produce seed, they appear to die back, but actually they go into a resting period called dormancy. This process is more noticeable in regions that have cold winter seasons. The perennial may completely stop growing for the winter. However, when spring comes, its pattern of growth begins again. During the dormant period, the perennial slows down all its natural processes. Dormancy is a means by which plants protect themselves from the colder temperatures. Many forage (animal feed) and pasture crops are perennials. Trees, shrubs, and some flowers used in landscaping are perennials also. Most lawn grass species are perennial plants.

Summary

Because plants are vital to human survival, knowledge and understanding of the plant kingdom are beneficial. Both botanical and descriptive classifications provide a means for communication. Research will continue to provide ways to meet the growing demand for food and plant products.

Credits

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Lesson 3:
Plant Growth Factors

In order to discuss the process by which plants grow, a definition of plant growth is needed. Plant growth is an irreversible process during a plant's life that increases plant volume or dry weight or both. Scientists and agriculturalists are concerned with factors that affect plant growth. Understanding the factors that influence plant growth is beneficial to everyone, including consumers who purchase food at the grocery store.

Factors Affecting Plant Growth

Plant growth is affected by the environment. Factors that affect plant growth are light, water, nutrients, and temperature. Each factor affects specific processes or a combination of processes within the plant that directly relates to plant growth and development.

Light

Light is essential for plant growth. Normal plant growth requires the full range of the visible spectrum of sunlight. Plants react to light through the processes of photosynthesis, phototropism, and photoperiodism.

Photosynthesis - Photosynthesis is a chemical process that takes place within plant cells. Photosynthesis changes nonliving materials into food. Through photosynthesis, water (H_2O) and carbon dioxide (CO_2) in the presence of light are converted into energy-rich organic compounds (sugars). Once these sugars (carbohydrates) are formed, they can be changed or transformed into starches. Products from the process of photosynthesis are used by the plant as food for growth and development.

Phototropism - Phototropism is a term for the reaction of plants caused by exposure to light. In the process of plant growth, organic chemical substances within the plant are involved. These chemical substances, which are known as hormones (growth regulators), can either promote or inhibit growth. In phototropism, the hormones stimulate longitudinal growth of the plant's stem. As the hormones move throughout the plant's phloem system, they affect other growth processes such as seed germination, flower initiation, flower growth, and pollen-tube growth.

Phototropism causes the plant to bend and grow toward light. The reason for this bending action is the accumulation of hormones on the dark side of the plant. The accumulation of hormones causes the cells to become elongated. Cell elongation causes the stem to bend towards the light. Phototropism stimulates plant growth through movement of the plant.

Photoperiodism - One other plant reaction to light is photoperiodism. Photoperiodism is the growth response of plants caused by the number of light and dark hours in the day. Photoperiodism is commonly referred to as "day length." In the process of plant growth, formation of the flower is vital in the production of seed. In many plant species, flower formation depends upon day length. By understanding the plant species' photoperiodism requirements, flowering can be manipulated in controlled environments such as greenhouses. Not all plants need a specific length of daylight hours to produce flowers. However, all plants require light to complete their life cycles and continue to produce more seeds.

Water

Water is considered an essential element in plant growth. Depending on the plant, moisture content can vary from 15 percent to 95 percent of the plant's "fresh" weight, or weight of green material. When moisture is removed, the actual weight of "dry" matter can be calculated. Water provides a means by which minerals can be taken up and transported throughout the plant. Water is involved in many chemical reactions throughout the plant. Although all plants require water, the amount of water required differs with each plant species.

Nutrients

Plants also have nutritional needs in order to grow and develop properly. The greatest percentage of the content of a herbaceous plant (a plant that lacks woody tissue) is water. Plant dry matter consists of three main elements: carbon, hydrogen, and oxygen. These three elements are

made available to the plant by water, carbon dioxide, and oxygen. Plants also require thirteen other essential elements for proper growth. These elements can be divided into two groups: macronutrients and micronutrients.

Plants require larger amounts of the macronutrients than micronutrients. The macronutrients include: nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Macronutrients can be divided into primary and secondary categories. Primary macronutrients are nitrogen, phosphorus, and potassium. Secondary macronutrients are calcium, magnesium, and sulfur. To better understand the plant's need for the macronutrients, see Table 3.1, which lists the nutrients and their functions.

Micronutrients are those that plants require in small amounts (parts per million, ppm) per unit of plant dry matter. Micronutrients are: boron, manganese, copper, zinc, iron, chlorine, and molybdenum.

Methods to Obtain Nutrients

Plant growth depends on the availability of the essential nutrients. In order for nutrients to be helpful to the plant, the plant must be able to bring them up into its structure. A plant obtains nutrients by the processes of absorption and osmosis. Nutrients are then transported throughout the plant by translocation. During the transpiration process, oxygen is released into the atmosphere through the stomata in the leaves.

Absorption is the process through which plants absorb nutrients and water from the soil through its roots. Absorption is most active just above the root tip in the region of the hair roots. Once water and nutrients have been absorbed into the plant, they are then used for various needs.

Table 3.1 - Macronutrients

Primary Macronutrients	**Use of nutrient in plant**
1. Nitrogen	Needed in making proteins Increases plant green color Promotes rapid growth
2. Phosphorus	Promotes early root formation Promotes vigorous start Hastens maturity
3. Potassium	Increases vigor and disease resistance Increases strength of stalks Increases gain size
Secondary Macronutrients	**Use of nutrient in plant**
4. Calcium	Promotes early root formation Improves general plant vigor Component of cell walls
5. Magnesium	Part of chlorophyll Aids in formation of sugars
6. Sulfur	Promotes increased root growth Helps maintain dark green color

During absorption, molecules of water and nutrients outside the plant's roots are taken up into the plant. The movement of molecules through permeable membranes is known as diffusion. As water passes through these membranes, it is referred to as osmosis. The movement of water and the flow of larger molecules is caused by pressure differences within the plant known as hydrostatic pressure.

Temperature

Temperature can influence plant growth positively or negatively. Because plants have large surface areas, it is difficult for them to regulate their own temperature. Temperatures above or below the optimum growing temperature of 68° to 95° will reduce carbon fixation within the plant. When temperatures drop, plant processes slow down. Chemical reaction rates also slow down at cooler temperatures. Gaseous exchange decreases, and diffusion and osmosis slow down because the permeability of membranes is more difficult. Colder temperatures reduce the growth rate of plants.

As temperatures rise past the optimum, plant growth is also reduced. As the temperature rises, enzymes become less stable and break down causing plant inactivity. Many processes within the plant are affected by temperatures. Consequently, plant growth is reduced as temperature rises above the optimum. The optimum growing temperature varies for each plant species.

Summary

Understanding the factors that influence plant growth is important to understanding the process of plant growth. The plant kingdom is very dependent upon the environment. The availability of light, clean water, essential nutrients, and optimum temperature all affect plant growth. Humans are equally dependent upon the plant kingdom. Caring for the environment will help to ensure the continued supply of food for the world.

Credits

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Lesson 4:
Weeds, Diseases, Insects

Many areas of the world are plagued by food shortages because of pests. High percentages of crops are lost due to pest damage. Each year, billions of dollars are spent to research the causes of crop damage and possible ways to prevent crop loss due to pests. Plant growth depends on a combination of external factors and internal processes. Successful production of food and fiber crops involves more than just plowing the soil, planting the seeds, and waiting for harvest. Many factors must be managed for successful plant growth.

Plant Pests

Plant pests include all life forms that cause damage to plants. Pests can range from the smallest living organism, such as bacteria, to a deer that wanders into a field and eats or tramples a corn crop. Pests are commonly categorized into three groups: weeds, diseases, and insects.

Weeds

As was discussed in Lesson 3, plants need sunlight, water, and essential nutrients for growth and development. All plants, including weeds, require these elements. Therefore, weeds compete with crop plants for nutrient elements.

Each year American farmers lose billions of dollars because of weeds. Weeds can inhibit crop growth and lower crop quality. Weeds are vigorous in their competition for plant nutrients and often develop an immunity to other pests. Weeds often overpower crops when their seed germination rates are higher and emergence occurs before the food crop. Weeds can populate an area quickly and steal the essential nutrients before crop plants can absorb the needed nutrients.

Diseases

Healthy plants are able to carry out normal physiological functions. Normal physiological functions include: cell division, development, absorption of water and essential nutrients from the soil, translocation, photosynthesis, food storage, reproduction, and overwintering.

Normal plant functions can be affected by either adverse environmental conditions or a combination of harmful factors. When normal plant functions are altered beyond some tolerance point, the plant may become diseased. The major causes of disease are environmental conditions under which plants are exposed to pathogenic living organisms (pathogens). Pathogens are organisms that transmit diseases.

Plants respond differently to various diseases. However, most diseases are harmful to plants. Injury to plant tissues and cells reduce the plant's ability to produce food through photosynthesis. The reduction of photosynthesis can stunt the growth of the plant or kill it entirely. Diseases affecting tissues and cells also affect the plant's structural strength. Weakened structural strength increases crop losses due to reduced yields and quality.

Condition for Diseases

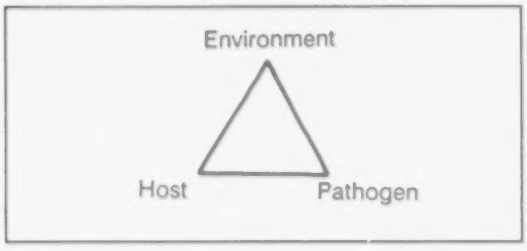
A plant can become diseased when it has been damaged or injured by environmental causes or attacked by a pathogen. In order for plant diseases to develop, certain conditions must be present: a susceptible host, a virulent pathogen, and a favorable environment.

A susceptible host refers to a weakened plant that comes in contact with a pathogen. Plants that have been injured or stressed are more susceptible to infection. Plant scientists and breeders have made great progress in developing disease-resistant crop varieties. In order for the disease process to start, the combination of the plant and pathogen must be favorable. Disease-resistant crop varieties reduce the possibility of a disease starting.

The second condition is the virulent pathogen. Not only does the plant need to be a susceptible host, the pathogen must carry the disease organism. A virulent pathogen is one that is able to successfully attack a plant and inflict the disease.

The third condition necessary for the development of a disease is the environment. When the first two conditions are present but the environment does not enhance that contact, no disease will develop. If the environment is too cold, too hot, too dry, or some other extreme, the disease may not develop at that time. These three conditions necessary for the development of a disease can best be illustrated in what is known as the disease triangle. (Figure 4.1) The absence of any one of the three factors will prevent occurrence of the disease. Disease control practices are directed toward eliminating one or more of the three factors.

Figure 4.1 - Disease Triangle



Insects

The presence of insects is a part of life. Insects need nourishment and shelter; plants provide both. Insects inflict damage to crops that cost producers and consumers billions of dollars annually. For example, the European corn borer can destroy up to 35 million dollars of the corn crop annually, and that is only one species of insect. However, not all insects are harmful to plants. Some insects actually help by destroying other harmful insects.

Insects inhibit plant growth in two ways: by causing physical damage or physiological damage. Physical damage is caused by insects attacking physical structures of the plant. For example, insects that are categorized as foliage feeders are chewing insects.

Foliage feeders are the largest group of insects. Foliage feeders chew on leaves, stems, and flowers. Some foliage feeders may bore themselves into the plant and eat the tissues inside the stem like the cutworms or army worms. Foliage feeders are found in large numbers and can do extensive damage in a short period of time.

Sap sucking insects also do physical damage to plants. Aphids and leaf hopper nymphs are species that attach themselves to plants and suck plant sap from the leaves and stems. Sucking the sap from the plant robs the plant of essential nutrients. Other physical damage caused by insects may occur on the roots, the seeds, or the fruit of plants. Attacking the physical structure often reduces plants to a weakened state and therefore more susceptible to disease.

Physiological damage refers to disruption of natural processes within the plant. Photosynthesis, respiration, and translocation of nutrients and water throughout the plant are examples of physiological processes. Physiological damage to the plant may also be caused by insects. Insects are considered vectors. A vector is a carrier. Vectors can be beneficial by carrying pollen and aiding in the pollination of plants. Vectors can also be harmful by carrying disease-causing organisms from plant to plant. Insects can also cause physiological damage to plants by depositing their eggs on or within the plant. Insect eggs can inhibit certain growth processes or even destroy the plant.

Summary

Plant growth damage from pests continues to destroy portions of the world's food supply. Pests such as weeds, diseases and insects reduce yields and crop quality. Researchers continue to work to develop crop varieties that can resist pests and therefore reduce crop losses.

Credits

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Lesson 5:
Germination

In order for a viable seed to germinate, certain environmental conditions must be met. This lesson will discuss what seeds are, how they germinate, and how emergence differs between a monocot seed and a dicot seed.

Seeds

A seed is a young embryonic (living organism in an early stage of development) plant in a dormant or resting stage. Each seed contains a supply of food and one or more seed coats. Seeds come in many sizes, shapes, and colors. Seeds can be planted to produce another plant or eaten as foods like popcorn, peanuts, or cooked beans. Regardless of the shape or color, all seeds contain three basic parts: an embryo, a food supply, and an ovary wall (seed coat).

The seed is alive even though it is in a dormant stage. Proper care of seeds during dormancy is vital. Improper storage conditions such as extreme moisture, heat, or cold may damage the seed and cause it to die. In order for a seed to germinate, it must be a viable (capable of living or growing) seed.

Germination

A seed must germinate in order for the young plant to begin to grow and develop. Germination of a viable seed occurs when a seed has been exposed to certain environmental conditions that stimulate the process. Favorable temperature, sufficient moisture, and air (specifically oxygen) are three environmental conditions necessary for germination. However, due to difference in plants, the degree to which these environment conditions are required will vary. Some ornamental bedding plants require light to begin the germination process. However, light will inhibit germination of most agronomic crops.

Seed germination involves several steps. The first step in germination is absorption of water by the seed. Seeds will generally absorb 35 to 100 percent of their weight in water. Absorption of water causes the seed coat to swell. When penetration of water and swelling of the seed occurs, the seed's proteins are activated.

The second step of activating the seed's proteins involves the activation of the seed's enzyme system. Increased enzyme activity in the seed stimulates the growth of the embryo. The embryo's rapid growth requires more moisture and oxygen.

Emergence of the root structure from the seed is the third step. The new root anchors the seed in the soil and absorbs moisture for continued growth.

The fourth step in the germination process is the emergence of the shoot from the seed. Because the seed has a limited supply of food, the plant must soon begin producing its own food. The shoot of the embryo will push its way up through the soil into the sunlight.

Once the shoot has emerged from the soil, the last step can take place. The last step is the formation of leaves and the production of food through photosynthesis. The plant begins to grow and develop after the process of germination has been completed.

Monocot Seeds

Monocot and dicot seeds require three environmental conditions for germination. However, when comparing seeds of monocots and dicots, the parts and functions are different.

The monocot seed consists of a seed coat, endosperm, and embryo. The embryo contains the cotyledon, epicotyl, hypocotyl, and radicle. See Figure 5.1 for parts.

Each part of a monocot seed has a unique purpose. The seed coat is the tissue surrounding the embryo, which protects the inner parts. The endosperm is a source of starch or energy (food) for the miniature plant until germination is complete. After germination, the plant produces its own food through photosynthesis.

The embryo is a miniature plant within the seed structure. The embryo contains the cotyledon (scutelum), which breaks down the starch in the endosperm to provide food for the embryo. The

Figure 5.1 - Monocot Seed (Corn)

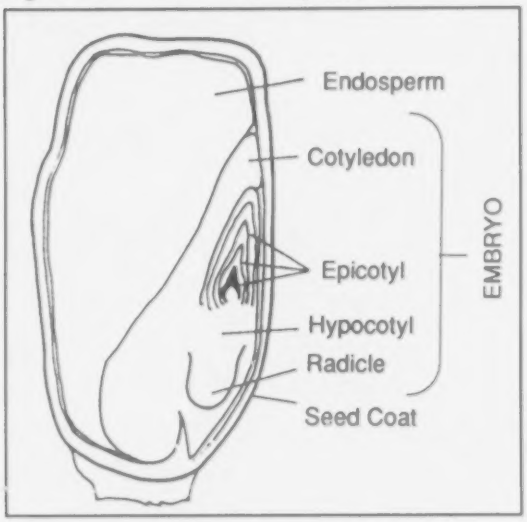
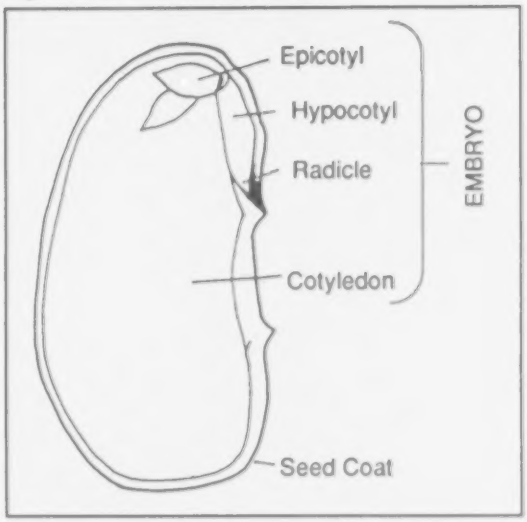


Figure 5.2 - Dicot Seed (Bean)



epicotyl is the shoot above the cotyledon. This part grows above the ground. The hypocotyl is the part of the stem below the cotyledon. The radicle develops into the primary root of the plant. The radicle absorbs water during germination. The radicle dies after other permanent roots have formed.

Dicot Seeds

Figure 5.2 is an example of a dicot seed. The parts of the dicot seed consist of the seed coat and the embryo. The embryo contains two cotyledons, the epicotyl, the radicle, and the hypocotyl. The purpose of the seed coat is to protect the embryo during the dormant stage. The two cotyledons store food during dormancy. The epicotyl forms into the first true leaves, shoot, and everything above the cotyledons. The hypocotyl is the first true stem between the root and first node of the stem. As the hypocotyl straightens upright, it pulls the cotyledons up out of the ground. The radicle forms the root system.

Germination and Emergence

During the germination process, tender parts of the young plant emerge from the soil. Emergence of the young plant is vital to begin photosynthesis. The emergence process of the young monocot plant is quite different than that of the dicot plant.

Germination and emergence of a monocot seed starts with the swelling of the seed due to absorption of water. Moisture stimulates enzyme activity and the seed coat ruptures. The radicle is the first part of the miniature plant to emerge from the seed. During the next step, the epicotyl grows out of the seed and starts pushing its way up through the soil towards the sunlight.

After the epicotyl emerges, new leaves form and food production begins through photosynthesis. A new root system forms above the first internode just beneath the soil surface. The temporary root system ceases to function and dies.

The process of germination and epigeal emergence, which occurs in most dicot seeds, also begins with the seed swelling and rupturing due to the absorption of water. The hypocotyl is the first part to grow out of the seed. The hypocotyl begins to elongate and forms an arch that breaks the soil surface. Once the hypocotyl reaches light, elongation ceases. The hypocotyl then straightens up and pulls the cotyledons out of the soil. Once the cotyledons have been exposed to light, they turn green and begin to manufacture food. When new leaves develop, the cotyledons dry up and fall off. The radicle extends downward into the soil to form roots during germination.

Figure 5.3 - Germination and Emergence of A Monocot Seed (Corn)

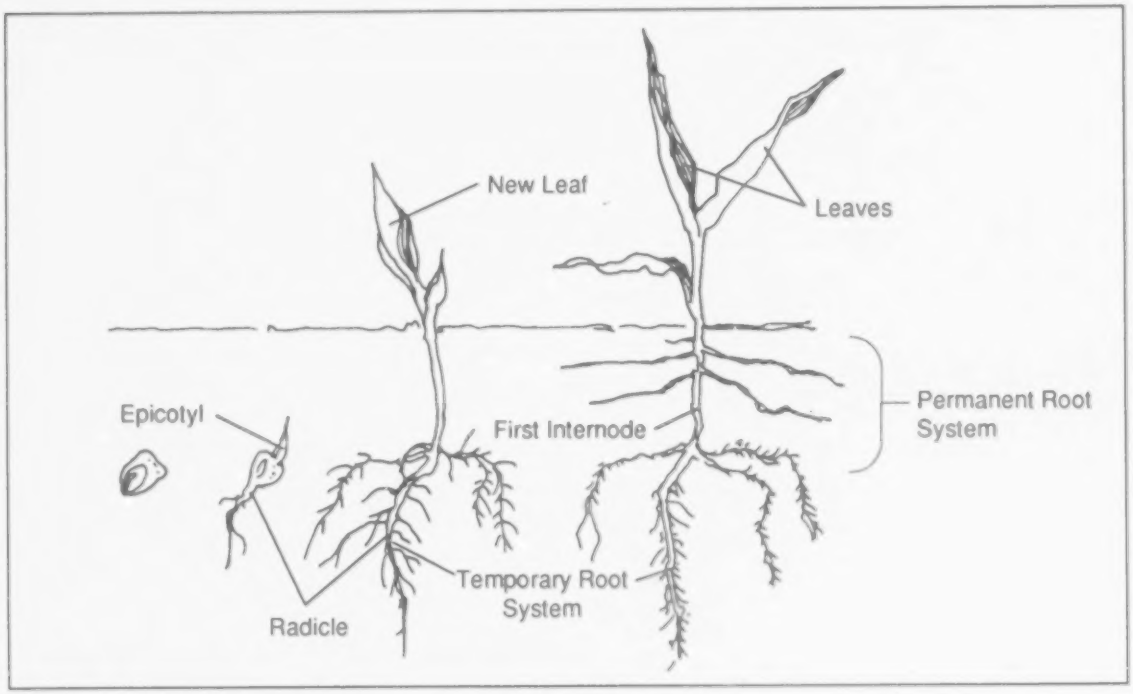
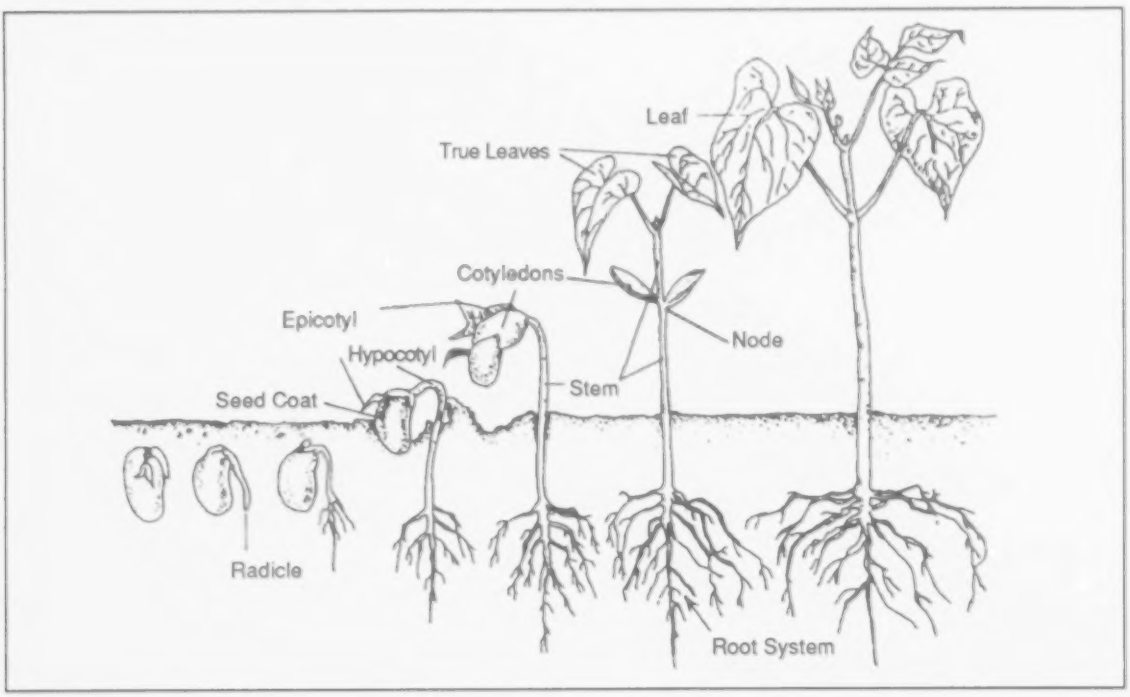


Figure 5.4 - Germination and Emergence of a Dicot Seed (Bean)



Summary

Seeds are the beginning of a plant's life cycle. Seeds are also an important food source throughout the world. Knowing the parts and functions of seeds, and the factors that affect germination and emergence are important to develop an understanding of how plants grow. In both monocot and dicot seeds, each part of the seed performs functions that are vital in the process of germination.

Credits

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Lesson 6:
Photosynthesis and Respiration

Basic Plant Processes

There are five basic processes that plants depend on for growth. In order to grow plants properly, it is important to understand how these processes affect plant growth. These processes include: photosynthesis, respiration, water absorption, translocation, and transpiration.

Movement of Nutrients and Water

The movement of water and nutrients in a plant involves three processes: transpiration, translocation, and absorption.

Transpiration is the loss of water by evaporation through the leaf surface. Although it occurs primarily through the leaf surface, it also occurs from the stems and petals. Transpiration occurs when the plant's stomata open to take in carbon dioxide, needed for photosynthesis. Transpiration is greatly influenced by environmental factors such as light, temperature, humidity, and wind. As more water is lost to transpiration, more water must be absorbed by the plant.

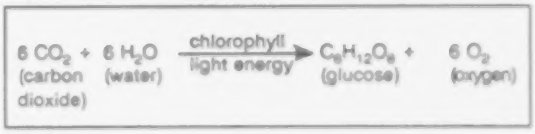
Translocation is the movement of water and organic compounds within the plant. The vascular system consists of canals of xylem and phloem tissues through which translocation occurs. Water and dissolved minerals are primarily translocated upward from the roots through the xylem tissues. This is due to tension in the xylem tissue caused by the continuous water column. This tension, produced by transpiration, is transmitted to the absorbing cells in the roots, triggering them to absorb more water. Organic compounds (sugars and starches) are translocated through the phloem tissues from areas of high concentration to areas of low concentration. Primarily it is from the leaves to the rest of the plant, including the root system.

Water and dissolved minerals are absorbed by plant root hairs. Absorption of water and dissolved minerals from the soil into plant root cells is by the process of osmosis. Osmosis is a type of diffusion. Diffusion is the movement of molecules from an area of higher concentration to an area of lower concentration. Osmosis is the diffusion of water through a differentially permeable membrane. For example, the membrane surrounding plant cells will allow some molecules and materials--depending on their chemical properties and size--to pass through easily and quickly. Other materials are allowed to pass through very slowly. Still other materials are blocked from entering.

Plant Food Production - Photosynthesis

Photosynthesis is the process through which green plants convert carbon dioxide and water in the presence of light into simple sugar (food). The formula is illustrated in Figure 6.1.

Figure 6.1 - Photosynthesis Formula

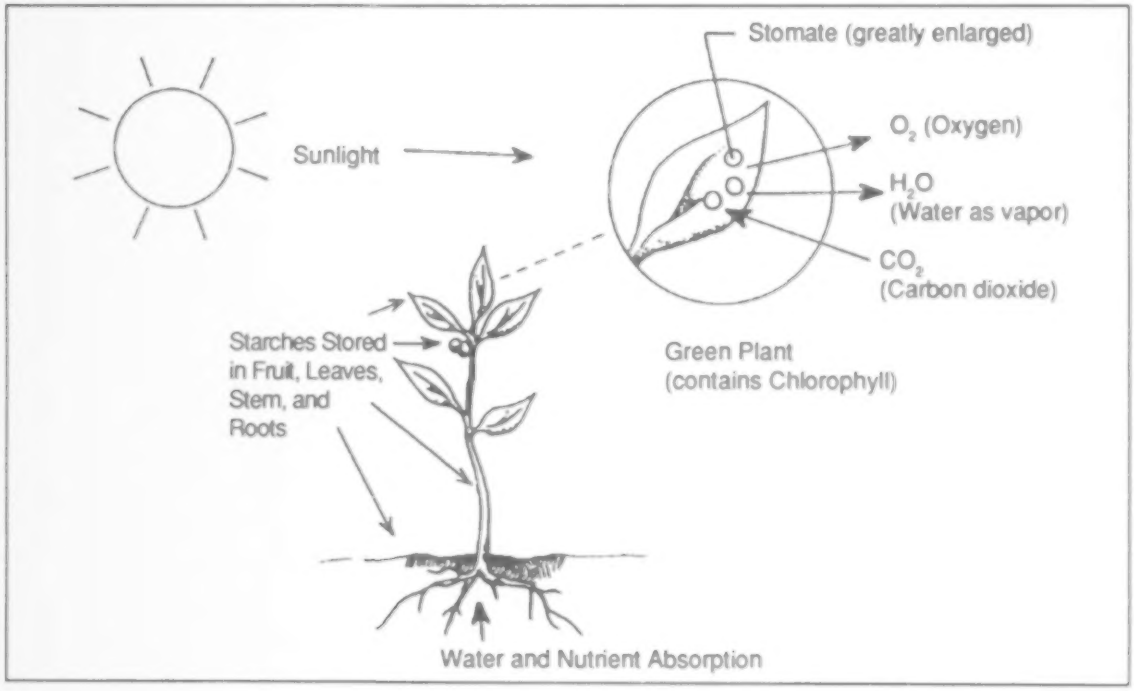


Carbon dioxide enters the plant through stomata, primarily located on leaves. Water is absorbed through root hairs and moves to the leaves through the xylem tissues. Light strikes the chlorophyll, which is present in the cells of the leaf and stem. Light energy is absorbed, enabling a chemical reaction to take place between carbon dioxide and the hydrogen in water. Glucose, the most common carbohydrate and a simple sugar, is produced and transported by the phloem tissues to other parts of the plant. Oxygen is released as a by-product through the stomata. Water vapor is also released when the stomata open. See Figure 6.2.

Plants produce their own food through the process of photosynthesis. Plants use photosynthetically manufactured food for energy to perform the various processes necessary for plant growth. Plants also store food in the form of carbohydrates to be used by the plant when needed.

Respiration involves the breakdown of glucose. This process releases energy for plant growth, absorption, translocation, and many other processes occurring within the plant. Glucose

Figure 6.2 - Photosynthesis Process



molecules are combined and stored in the form of complex starch molecules in plant cells. Nearly all respiration occurs in the presence of oxygen (aerobic respiration). However, some cellular respiration may occur for a short time without oxygen (anaerobic respiration). The formula for aerobic respiration is illustrated in Figure 6.3.

Figure 6.3 - Respiration Formula

$$C_6H_{12}O_6 \text{ (glucose)} + 6\,O_2 \text{ (oxygen)} \longrightarrow 6\,CO_2 \text{ (carbon dioxide)} + 6\,H_2O \text{ (water)} + \text{energy}$$

Respiration enables the plant cell to release energy, which is used in energy-requiring chemical reactions within the cell. In addition, respiration releases carbon dioxide (CO_2) and water (H_2O) into the atmosphere. Respiration is a continuous process occurring throughout the day, for as long as the plant lives.

Figure 6.4 compares photosynthesis and respiration. Note that photosynthesis changes light energy from the sun into chemical energy. The chemical energy is stored in the form of glucose molecules. Respiration reverses the process by changing the chemical energy from the breakdown of glucose molecules into other forms of energy needed by plants.

Air Quality

The role of plants in improving air quality is vital. All forms of life need oxygen to survive. Plants produce oxygen as a by-product of photosynthesis. Excessive emissions from automobiles and industry damage plant life and lessen the production of oxygen by plants. Pollutants entering the atmosphere, the soil, and the water interrupt some plant processes. For plants to continue to grow and produce oxygen, humans need to keep the environment clean.

Summary

Five processes affect plant quality and longevity. Through the process of photosynthesis, a green plant manufactures its own food (simple sugar or glucose). The process of respiration breaks down

Figure 6.4 - Photosynthesis versus Respiration

	PHOTOSYNTHESIS	RESPIRATION
Energy relationships - (stored or released)	Stored	Released
Raw materials	CO_2 and H_2O	Glucose and O_2
Function	To convert sun energy into chemical energy	To release energy from glucose for cellular metabolism
End products	O_2 and glucose	CO_2, H_2O, and energy

glucose to release energy needed within plant cells. Water and dissolved mineral nutrients enter roots through the process of absorption. Translocation is the movement of water, dissolved minerals, glucose, and other organic compounds within the plant. Transpiration is the process of water loss from the plant primarily through stomata located on leaves. Plants play a vital role in improving air quality through the production of oxygen.

Credits

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Lesson 7:
Reproduction - Sexual and Asexual

Plant Reproduction

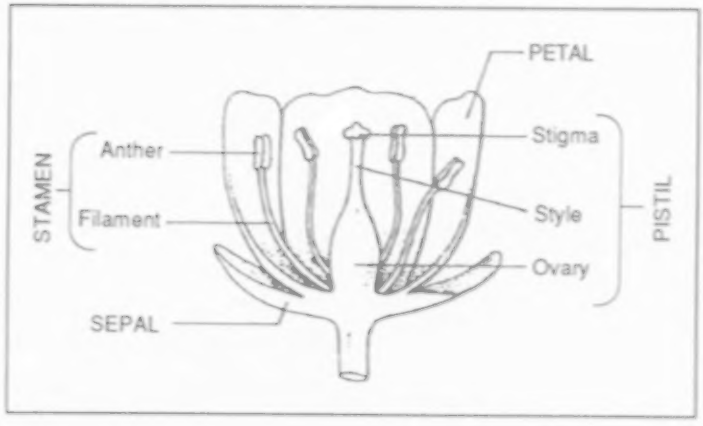
The controlled reproduction of plants is called plant propagation. There are two kinds of plant propagation: sexual and asexual. Sexual plant propagation uses seeds for producing new plants. Asexual plant propagation is the reproduction of plants using a vegetative part of the plant.

The Flower

Flowers contain the reproductive parts of plants involved in sexual reproduction. Flowers can have either male floral structures, female floral structures, or both. On some plant species, both male and female flowers can be found on the same plant. Plant flowers with male and female parts on the same plant are known as monoecious plants. Corn is an example of a monoecious plant with tassels (male flower) on top and silks on each ear (female flower). Dioecious plants have male and female flower parts on separate plants. Date palms and asparagus are examples of dioecious plants.

There are four parts of a flower: sepals, petals, stamens, and pistils. Sepals and petals are the vegetative parts of the flower. The stamens and pistils are the reproductive parts of the flower. Figure 7.1 illustrates the four parts of the flower as well as the parts that make up each stamen and pistil.

Figure 7.1 - Flower Parts



Sepals - When the flower bud is closed, an outer, scale-like covering is formed by the sepals. All of the sepals together are called the calyx. The function of the sepals is to protect the petals, stamens, and pistils when the flower is in the bud stage.

Petals - The petals are usually brightly colored to attract pollinators (usually insects). All of the petals together are called the corolla. The petals protect the stamens and pistils in the bud stage.

Stamens - The stamen is the male reproductive part of the flower. Each stamen consists of two parts: the anther and the filament. The anther produces pollen grains, and the filament supports the anther.

Pistil - The pistil is the female reproductive part of the flower. The pistil consists of the ovary, stigma, and style. The ovary is the enlarged portion at the base of the pistil. The function of the ovary is to produce ovules. Ovules that are fertilized become seeds. The stigma receives and holds the pollen grains. The style connects the stigma with the ovary. Pollen grains travel through the style to reach the ovary. The style supports the stigma.

Complete and Incomplete Flowers

A complete flower has all four main parts: sepals, petals, stamens, and pistils. An incomplete flower is missing one or more of the main parts of a flower.

Pollination and Fertilization

Pollination is the transfer of pollen from the anther of the stamen to the stigma of the pistil. The process of pollen transfer is the first step in pollination. Pollination can happen by either self-pollination or cross-pollination. In self-pollination, pollen is transferred from the anther to the stigma of the same flower or to other flowers on the same plant. Examples of plants that self-pollinate are oats, barley, wheat, and soybeans. In cross-pollination, pollen is transferred from the anther of one plant to the stigma

of another plant. Examples of plants that cross-pollinate are alfalfa, red clover, and rye.

Fertilization is the union of male and female cells to form the first embryonic cell and the first endosperm cell. Fertilization is the final step in sexual reproduction. There are four steps in fertilization:

1. Pollen sticks to the moist stigma, which provides favorable conditions for pollen germination.
2. As the pollen germinates, a long structure known as the pollen tube grows downward through the style into the ovary, contacting the egg cell.
3. As the pollen tube breaks open, one sperm cell unites with one egg cell, resulting in production of the zygote, or fertilized egg. This is the beginning of the embryo.
4. A second sperm cell unites with two other nuclei (polar nuclei), forming the endosperm.

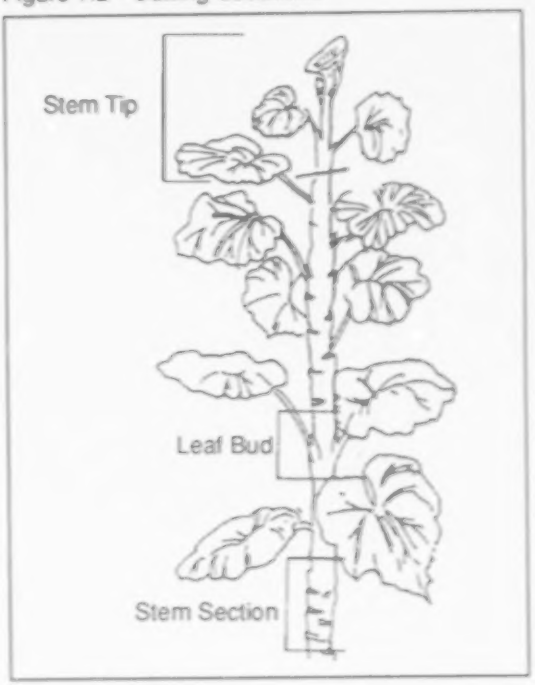
Conditions for Pollination and Fertilization

Pollination and fertilization occur when the plant reaches the proper stage in its life cycle and when the conditions are right. In self-pollination, the pollen must fall from the anther of the flower to the stigma of the same flower or another flower on the same plant. Gravity aids in self-pollination; however, favorable weather conditions are helpful. Weather conditions can either help or hinder pollination and fertilization. Favorable weather conditions with air movement (wind) can assist the transportation of pollen. Pollinators such as insects aid in the pollination process when they travel from flower to flower, seeking nectar. Favorable weather conditions and insects are crucial in cross-pollination, since the pollen must be transferred between plants.

Asexual Propagation

Asexual propagation of plants involves using plant parts to produce another plant. The plant parts used in asexual propagation are stems, leaves, and roots. Methods most commonly used in asexual plant propagation are cuttings, division, layering, budding, grafting, and tissue culture.

Figure 7.2 - Cutting Locations



Cuttings - Cuttings are plant pieces that are "cut" from the parent plant and rooted to form new plants. Cuttings may be taken from stems, leaves, and roots. There are four types of cuttings: stem tip, leaf, leaf and bud, and stem section. Figure 7.2 illustrates the location of stem tip, leaf bud, and stem section cuttings on a typical plant. Figure 7.3 shows a stem cutting.

Figure 7.3 - Stem Cutting

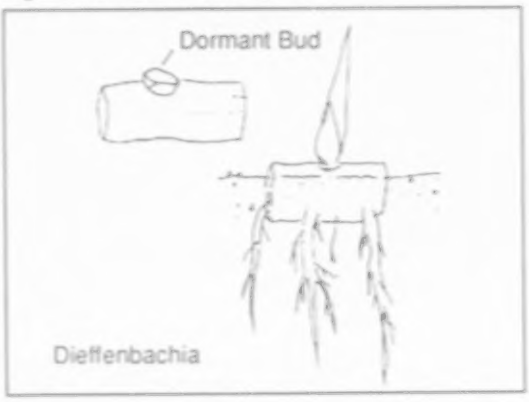


Figure 7.4 - Leaf Cuttings

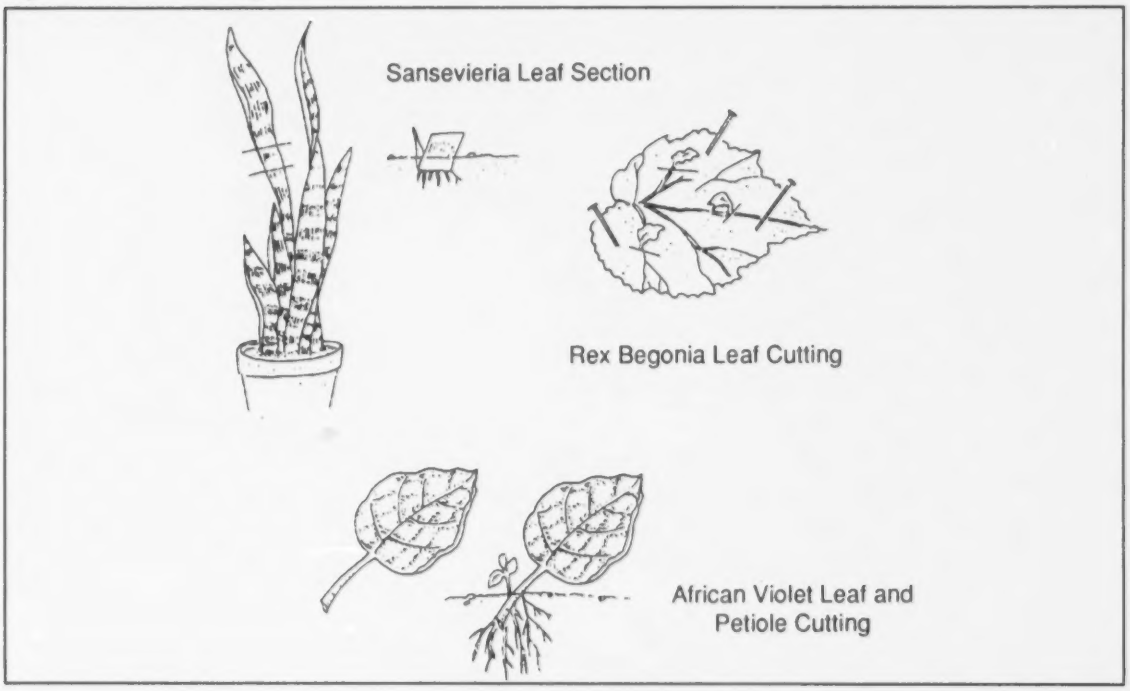


Figure 7.5 - Leaf and Bud Cutting

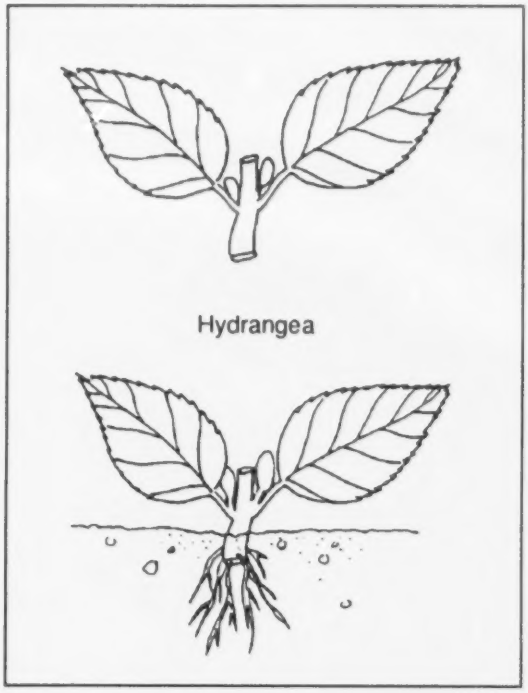


Figure 7.4 shows examples of leaf cuttings. Figure 7.5 is an example of a leaf and bud cutting.

Division - Division is a way to propagate plants by separating clumps of plants into smaller groups. Each small group would have roots, stems, and leaves or the potential to develop these parts. Division is the easiest way to propagate plants that produce offsets, basal shoots, or a multiple crown. See Figure 7.6.

Figure 7.6 - Division

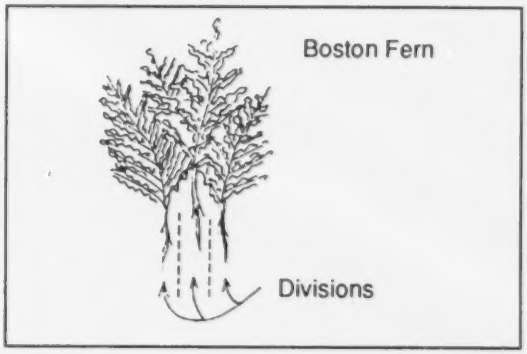


Figure 7.7 - Simple Layering

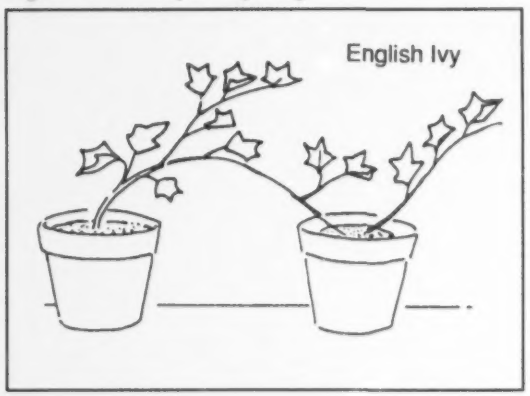
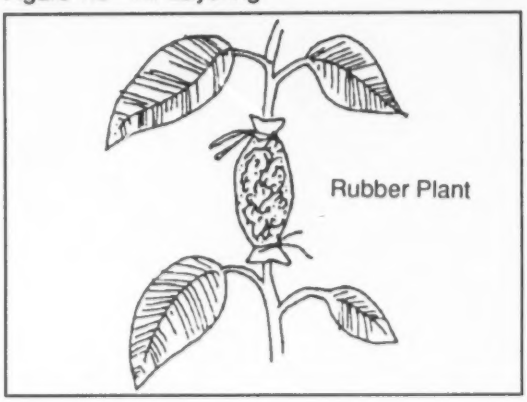


Figure 7.8 - Air Layering



Layering - Layering is a method of rooting a new plant while the stem is still attached to the parent plant. Types of layering include simple, tip, compound, mound, trench, and air. Simple and air layering are the most frequent types of layering used in greenhouses. Figure 7.7 illustrates simple layering. Figure 7.8 illustrates air layering.

Grafting - Grafting is a method of propagating plants by inserting buds, twigs, or shoots from one plant onto the stem of another plant. Grafting is used mainly to produce fruit trees.

Budding - Budding is a special form of grafting that uses a single bud, which is inserted into the bark of another variety. Budding is used on fruit trees, nut trees, and rose plants.

Tissue Culture - Tissue culture is a relatively new propagation technique in which a single cell or a small piece of plant tissue called the explant is taken from the meristematic tissue to produce a new plant. The explant is placed in a germ-free growing medium in a closed, sterile container. Plant vitamins and hormones are used to control root and shoot growth. When the plants are large enough to be handled, they are transplanted into individual pots and placed in a greenhouse.

Summary

There are two kinds of plant propagation: sexual, and asexual. Sexual plant propagation involves each stage of the plant's life cycle: pollination, fertilization, the formation of seed, and germination of the seed to produce another plant. Asexual plant propagation involves the use of plant parts to produce another plant. The methods of asexual plant propagation are cuttings, division, layering, grafting, budding, and tissue culture.

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Lesson 8:
Plant Genetics

Many factors contribute to the high production levels of quality food crops in the U.S. One very important factor is the application of knowledge gained through research in plant genetics. In this lesson, plant genetics, genetic engineering, and their effects on plant production will be discussed.

Inheritance

Inheritance is a term used in plant genetics that refers to the transmission of genes from one generation to the next. The genetic makeup of a plant determines the expression of traits (e.g., yield potential, flower color, and leaf structure). Many plant characteristics are transmitted from one generation to another. Genes are the smallest unit of inheritance, which transmit genetic information between generations.

Environmental factors will ultimately determine the extent to which the genetic potential of a plant is expressed. However, the genetic makeup of each plant dictates the potential for the expression of each plant characteristic.

Researchers have begun to manipulate the genetic makeup of plants. Desirable traits are retained, while undesirable traits are eliminated. Genetic manipulation involves the transfer of genetic material from one generation of plants to the next.

DNA and Genes

Chromosomes are located within the nucleus of each plant cell. Chromosomes consist of a sequence of DNA (deoxyribonucleic acid). Within the DNA chain, there are specific function-controlling segments called genes. Genes are the parts of a chromosome that determine individual plant characteristics. The overall function and importance of DNA is that it serves as a coding mechanism for heredity. DNA also contains information to control the synthesis of enzymes that control the basic metabolic processes of all cells.

Genetic Engineering

In 1866, an Austrian monk by the name of Gregor Mendel published a scientific paper reporting the results of his experiments. Mendel had been researching plant genetics and how specific characteristics are passed from generation to generation. Since Mendel's time, much work has been done in the area of plant genetics.

During the process of pollination, plants either self-pollinate or cross-pollinate to reproduce. This process involves sexual fusion of male and female cells. (Refer to Lesson 7 for more information on sexual reproduction.) Humans can intervene in this process of pollination by controlling and directing the cross-pollination of specific plants. Genetic engineering is quite different from controlling the pollination process. Genetic engineering is the process of transferring genes from one organism to another. This process can develop new plants known as somatic hybrids.

Biotechnology Benefits Crop Production

The term biotechnology is often used in a discussion of genetics or genetic engineering. Biotechnology is the use of technology in the study and research of living beings and life processes. Researchers use biotechnology in the study of plants for many reasons. Using biotechnology in plant production, researchers can genetically manipulate the production of crop plants. This manipulation has led to increased production levels to meet the growing demand for food. Genetic engineering can reduce the amount of time required to change the genetic makeup of a plant species. These new plants are known as somatic hybrids.

Genetic engineering can also increase beneficial characteristics of plants. Insects and diseases can decrease plant growth and food production. Introducing disease-resistant traits into plants through genetic engineering can enable plants to produce under adverse conditions.

Ethics

Genetics is basic to all living organisms. Therefore, the genetic engineering techniques used on lower life forms are theoretically applicable to higher life forms. Ethical considerations are important factors to consider when making decisions about genetic engineering. Genetic manipulation changes the makeup of a living organism from an occurrence in nature to a product of

science. Consideration of the motives for the research, safety during the research, and application of the findings must be part of the decision making process. Social and consumer acceptability, environmental impact, and the costs versus the benefits of genetic engineering should also be considered. Genetic engineering has become a controversial issue in scientific research. However, there is usually less public concern with genetic engineering in the plant kingdom than in the animal kingdom.

With a continually growing world population, the need for food confronts everyone daily. Plant scientists, geneticists, and agriculturalists work to address specific food shortage problems. Not all countries are able to produce adequate amounts of food crops, yet the need for food for their citizens is very real. Working with genetic engineering, modified plants can be developed to grow and produce in harsh environments. Genetic research with plants is conducted to find more efficient ways to produce quality food crops.

Summary

Plant genetics is a highly technical area of science. Research on the inheritance of specific traits, DNA, genes, and genetic engineering of desirable traits continues to address the growing need for food through plant production. As plant geneticists work toward improving plants, ethical considerations must be an integral part of that process.

Credits

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